TRANSACTIONS OF THE

American Foundrymen's Association

Proceedings of the

Twenty-fourth Annual Meeting

PHILADELPHIA, PA.

September 29 to October 3, 1919

VOLUME XXVIII

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and

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Summary of the Proceedings of the Twenty-fourth Annual Meeting

Philadelphia, Pa., Sept. 29 to Oct. 3, 1919.

Notable progress, both in the design, development and manufacture of metal-working and foundry equipment and in the solution of problems affecting casting practice and foundry administration, was indicated in the meetings and exhibition of the twenty-fourth annual convention of the American Foundrymen's association at Philadelphia. Free from the restraint of war time activities, foundrymen attended the meetings in greater number than ever before in the history of the association. Among those who registered during the week were foundrymen from many foreign countries including England, France, Norway, Japan, India, Java and Australia.

Sharply in contrast with the 1918 convention, the meeting at Philadelphia reflected an enthusiastic tendency on the part of foundrymen to attack the problems of reconstruction. For the first time in the history of the association a session was devoted to the subject of industrial relations. Recognition of the gravity of the labor situation confronting the country was given in a communication sent to the senate committee investigating the steel strike, following its unanimous adoption at the final session on Friday.

The first session on Tuesday, Sept. 30 was conducted jointly with the Institute of Metals division of the American Institute of Mining and Metallurgical Engineers. There were two sessions on general topics on Wednesday and Friday, respectively. A session devoted especially to steel foundry problems was held simultaneously with the general session Wednesday and on Thursday, gray iron, malleable and industrial rela-

tions sessions were held simultaneously. An extensive discussion on welding problems was a feature of the final session on Friday. The great volume of work accomplished may be measured from the fact that there were 43 papers and 11 committee reports on the program. Upon recommendation of the committee on foundry costs, the association decided to publish the American Foundrymen's association uniform foundry cost keeping system, which appears elsewhere in this volume.

Joint Opening Session

Tuesday, Sept. 30, 10 a. m., Ball Room, Bellevue-Stratford

The convention was formally opened by a joint opening session of the Institute of Metals division of the American Institute of Mining and Metallurgical Engineers and the American Foundrymen's association in the ballroom, Bellevue-Stratford hotel, at 10 a. m., Tuesday, Sept. 30.

A. O. Backert, president of the American Foundrymen's association, occupied the chair. The annual address of the president was read by Mr. Backert, after which he read the following letter from Thomas H. Firth, past president of the British Foundrymen's association:

SHEFFIELD

A. O. Backert, president,
American Foundrymen's Association,
Cleveland, Ohio.

Dear Mr. President:

Although my term of office as president of the British Foundrymen's association has just expired, it gives me great pleasure as representative of the casting interests of the United Kingdom to send a message of good will and a friendly greeting to the American Foundrymen's association and the large number of foundrymen who will attend your convention and exhibition at Philadelphia on September 29. I only regret that stress of work and the uncertainty of labor conditions at present obtaining in this country prevent me from accepting your warm and pressing invitation to deliver my message in person, and from giving such support as I could to a convention with such extensive and useful aims.

Whatever tends to cement the bond of friendship between the two great English-speaking nations, whatever tends to promote harmony and co-operation between them, and whatever increases their cordial relations in commerce tends also to further the future peace and progress of the world.

With regard to the objects of your convention and exhibition, it is our sincere hope that from every standpoint it will prove a complete

success. We know that yours was the pioneer association of foundrymen, and it was on your association that those of this and other countries were modeled. The debt which is owed to the investigations of such men as Keep, Moldenke, Outerbridge, West and others of your members is universally recognized. The splendid work accomplished by your various committees is generously appreciated. Their investigations and experiments on improved methods of molding, casting, testing and reports on methods of analysis and casting, have been of the greatest value to iron founders of this country and on the continent, and have been widely and carefully studied.

With our own methods and shops you will doubtless deal in the report which you intend to present of your recent visit to the iron foundries of this country, and it is by this mutual and friendly exchange of views and ideas that the two associations will profit, and from which will accrue considerable advantage to both.

The increase of labor unrest and the continued high cost of living are undoubtedly disturbing factors in commerce today, and it is now generally recognized in this country and also in America that the one thing on which the future success of all industry depends, and which alone can preserve the comparatively low price level of iron and steel products, is increased output. To effect this must be our first and foremost aim.

Please accept my warmest regards and best wishes for the success of your association convention and the renewed assurance of our good will.

Yours sincerely,

THOMAS H. FIRTH.

The following letter from Ivan Lamoureux, secretary of the Belgian Foundrymen's association, was received too late to be read during the convention:

(Translation)

Liege, Belgium

Mr. A. O. Backert, president,
American Foundrymen's association,
Cleveland, Ohio. Sept. 8, 1919.

Dear Sir:

I have the honor of expressing to you my sincere thanks for your kind invitation to the interallied congress in Philadelphia from September 29 to October 3.

I regret not being able to come to your beautiful country because the departure of the barbarian hordes from our unhappy land has left us much ruin and so much misfortune that we must all throw ourselves with all our energy into the work of reconstructing our industries which formerly were so fresh.

I have transmitted your invitation to my confreres who find themselves in the same position as myself.

I beg you to believe, Mr. President, that the Belgian foundrymen feel for your country in general, and for your noble president, Mr. Woodrow Wilson, sentiments of admiration and of gratitude.

We have admired the enthusiasm which accompanied your declara-

tion of war on those who broke all their bonds of honor, falsifying their given word and by acting contrary to all the laws of war and by instituting a reign of terror among defenseless populations. President Wilson has put an end to all the inhuman acts promoted by the central powers and he has established a foundation for the league of nations; and all humanity is following him as a leader.

We cherish our gratitude for the aid which you have brought to our invaded country both in sending us the necessities of life throughout the war and for the co-operation of your brilliant army which enabled the allied powers to drive from our country an execrated enemy.

President Wilson has also set forth in his own noble personality the ideal of your whole people, which I can summarize in the three words: Strength, wisdom and beauty.

I would have liked to bring to you in person the thanks of the Belgian foundrymen to their American confreres and at the same time to take part in the discussion of your important congress and to visit your beautiful exposition.

Please believe, Mr. President, that in thought I am with you and that I hope your congress will be a success which it deserves and that it will mark an unforgetable day in the annals of the foundry industry.

Please accept, Mr. President, my most paternal and distinguished sentiments.

IVAN LAMOUREX.

A. O. Backert, president of the American Foundrymen's association, then extended a welcome to foreign foundrymen, many of whom attended the convention.

An address of welcome was delivered by Thomas H. Devlin, president of the Philadelphia Foundrymen's association. John A. Penton, honorary member of the American Foundryment's association, spoke briefly in appreciation of Mr. Devlin's activities in behalf of the foundry industry. Mr. Cattell, statistician, city of Philadelphia, outlined the growth and importance of Philadelphia's institutions and industries.

Response to the address of welcome was made on behalf of the allied societies by J. P. Pero, past president of the American Foundrymen's association.

Following the address of welcome and response, President A. O. Backert announced the appointment of the following convention committees:

Nominating Committee.—Benjamin D. Fuller, chairman, Niagara Wall Paper Co., Niagara Falls, N. Y.; R. A. Bull, Duquesne Steel Foundry Co., Pittsburgh; J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.; Alfred E. Howell,

Phillips & Buttorff Mfg. Co., Nashville, Tenn.; and Stanley S. Flagg Jr., Stanley S. Flagg & Co., Philadelphia.

Committee on Resolutions.—Alfred E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; Charles Lundberg, Iron Age Publishing Co., Philadelphia; Thomas Pangborn, Pangborn Corp., Hagerstown, Md.; Lloyd Uhler, Union Steel Casting Co., Pittsburgh; and A. B. Root Jr., Hunt-Spiller Mfg. Corp., Boston.

The following reports and addresses also were presented at the joint opening session:

Report of the board of directors of the American Foundrymen's Association, Inc.

Report of the secretary-treasurer of the American Foundrymen's Association, Inc., by C. E. Hoyt, Chicago.

"The Need for Co-operative Research in Alloys," by Harrison E. Howe, National Research council, Washington.

"Considerations Affecting Brass Melting in Gray Iron Shops," by Russell R. Clarke, Eagle Brass Foundry, Seattle.

"The Weeks Electric Rotating Furnace as Applied to the Brass Foundry Industry," by F. J. Ryan, American Metallurgical Corp., Philadelphia.

"Publicity Work of Foundry Equipment Manufacturers' Association," by Franklin G. Smith, chairman publicity committee, Foundry Equipment Manufacturers association, Cleveland Osborn Mfg. Co., Cleveland.

General Session

Wednesday, Oct. 1, 10 a. m. Ball Room

A. O. Backert, president, American Foundrymen's association, in the chair.

The following papers and reports were presented and discussed:

"Audible Signals in Foundries," by Prof. Vladimir Karapetoff, Cornell university, Ithaca, N. Y.

"The Care of Foundry Equipment," by G. L. Grimes, Grimes Molding Machine Co., Detroit.

"How to Secure Best Results in Combining Hoisting

Apparatus with Molding Machines," by W. C. Briggs, Shepard Crane & Hoist Co., New York.

"Foundry Sand Handling Equipment," by H. L. McKinnon, The C. O. Bartlett & Snow Co., Cleveland.

"Concrete Foundry Molding Floors," by H. H. Haley, American Foundry Equipment Co., New York.

Report of the American Foundrymen's Association Committee on Foundry Costs, by J. Roy Tanner, chairman, Pittsburgh Valve Foundry & Construction Co., Pittsburgh.

"Uniform Methods of Cost Accounting," by C. E. Knoeppel, C. E. Knoeppel & Co., New York.

"The One Best Way to Do Work," by Frank B. Gilbreth and L. M. Gilbreth, Providence, R. I.

Dr. W. P. Wilson, director, Philadelphia Commercial Museum, explained the work of that organization.

Steel Session

Wednesday, Oct. 1, 10 a. m., Clover Room

R. A. Bull, past president, American Foundrymen's association, in the chair.

The following papers and reports were read and discussed:

"Electric Versus Converter Steel," by John Howe Hall and G. R. Hanks, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

"Effect of Sulphur in Steel Castings," by Prof. A. E. White, University of Michigan, Ann Arbor, Mich.

"Repairing Castings on Transport Northern Pacific," by Arthur F. Braid, Metal & Thermit Corp., New York.

"Comparison of Costs of Electric and Open-Hearth Furnace Practice," by E. H. Ballard, West Lynn, Mass.

Report of the American Foundrymen's Association Committee on Steel Foundry Standards, by W. A. Janssen, chairman, American Steel Foundries, Chicago.

"Operation of the Acid Electric Furnace," by L. B. Lindemuth, Carney & Lindemuth, New York.

"Values of the Present Methods of Measuring the Temperature of Molten Steel," by F. W. Brooke, Electric Furnace Construction Co., Philadelphia.

Unanimously decided to create a committee to arrange for co-operation with other organizations in studying sulphur problem.

GRAY IRON SESSION

Thursday, Oct. 2, 10 a. m., Ball Room

W. A. Janssen, vice president, American Foundrymen's association, in the chair.

The following papers and reports were read and discussed:

"Side Blow Converter in Iron Foundry," by George P. Fisher, Whiting Foundry Equipment Co., Harvey, Ill.

"Cerium in Cast Iron," by Dr. Richard Moldenke, Watchung, N. J.

"The Testing of Clays for Foundry Use," by Homer F. Staley, bureau of standards, Washington.

"The Value of a Scrap Pile," by Henry Traphagen, Toledo Steel Castings Co., Toledo, O.

"The Elimination of Strains in Iron Castings," by C. J. Wiltshire, General Electric Co., Schenectady, N. Y.

"The Electric Furnace as an Adjunct to the Cupola," by George K. Elliott, Lunkenheimer Co., Cincinnati.

Report of the American Foundrymen's Association Committee on General Specifications for Gray Iron Castings, Dr. Richard Moldenke, Watchung, N. J.

GENERAL SESSION

Thursday, Oct. 2, 12:30 p. m., Ball Room

A. O. Backert, president, American Foundrymen's association, in the chair.

The report of the nominating committee was unanimously accepted and the following directors were elected for the year 1919-20:

H. R. Atwater, Cleveland-Osborn Mfg. Co., Cleveland; A. O. Backert, The Penton Publishing Co., Cleveland; W. R.

Bean, Eastern Malleable Iron Co., Naugatuck, Conn.; R. A. Bull, Duquesne Steel Foundry Co., Coraopolis, Pa.; H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I.; S. B. Chadsey, Massey-Harris Co., Ltd., Toronto, Ont.; A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.; W. A. Janssen, American Steel Foundries, Chicago; S. T. Johnston, S. Obermayer Co., Chicago; C. S. Koch, Fort Pitt Steel Castings Co., McKeesport, Pa.; C. R. Messinger, Sivyer Steel Casting Co., Milwaukee; V. E. Minich, American Foundry Equipment Co., New York; J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.; A. B. Root Jr., Hunt-Spiller Mfg. Corp., Boston; J. Roy Tanner, Pittsburgh Valve Foundry & Construction Co., Pittsburgh; and C. E. Hoyt, Chicago.

Malleable Session

Thursday, Oct. 2, 10 a. m., Clover Room

W. R. Bean, director of American Foundrymen's association, in the chair.

The following papers and reports were read and discussed:

"Burning Fuel Oil in an Air Furnace," by J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.

"The Application of Powdered Coal to Malleable Annealing Furnaces," by Charles Longenecker, The Bonnot Co., Pittsburgh.

"Efficient Use of Pulverized Coal in Malleable Foundry Practice," by Milton W. Arrowood, Ground Coal Engineering Co., Chicago.

"Powdered Coal as a Fuel in the Foundry," by H. A. Grindle, Combustion Economy Corp., Chicago.

"Relation Between Machining Qualities of Malleable Castings and Physical Tests," by Edwin K. Smith and William Barr, Wisconsin Malleable Iron Co., Milwaukee.

"The Refining of Cupola Malleable in the Electric Furnace," by A. W. Merrick, General Electric Co., Schenectady, N. Y.

Report of the American Foundrymen's Association Com-

mittee on Specifications for Malleable Castings, by Enrique Touceda, chairman, Albany, N. Y.

"Some Needs of the Malleable Iron Industry," by W. P. Putnam, Detroit Testing Laboratory, Detroit.

"A Note on Britain's Experimental Foundry," by G. Ernest Wells, Edgar Allen & Co., Sheffield, Eng.

"Galvanizing Malleable Castings," by Prof. Enrique Touceda, Albany, N. Y.

"Effects of Annealing Gray and Malleable Iron Bars in Copper Oxide Packing," H. E. Diller, THE FOUNDRY, Cleveland.

INDUSTRIAL RELATIONS SESSION

Thursday, Oct. 2, 10 a. m., Red Room

C. B. Connelley, dean, Carnegie Institute of Technology, Pittsburgh, in the chair.

The following papers and reports were read and discussed:

"Training Men for Foundry Work," by C. C. Schoen, United States department of labor, Stamford, Conn.

"Personnel Problems of Modern Industry," by C. D. Dyer Jr., Hunt & Dyer, Philadelphia.

"Industrial Democracy and the Foreman," by John Calder, Business Training Corp., New York.

Report of the American Foundrymen's Association Committee on Safety, Sanitation and Fire Protection, by Victor T. Noonan, U. S. Mutual Liability Insurance Co., Quincy, Mass.

"Vocational Training for Foundry Occupations," by J. C. Wright, Federal Board for Vocational Education, Washington.

FINAL PROFESSIONAL AND BUSINESS SESSION

Friday, Oct. 3, 10 a. m., Ball Room

A. O. Backert, president, American Foundrymen's association, in the chair.

Announcement was made of the election of officers of the

American Foundrymen's association to serve for the ensuing year as follows:

President.—C. S. Koch, Fort Pitt Steel Casting Co., McKeesport, Pa.

Vice President.—W. R. Bean, Eastern Malleable Iron Co., Naugatuck, Conn.

Secretary-Treasurer.—C. E. Hoyt, Harris Trust building, Chicago.

With President-elect Koch in the chair, it was moved by Alfred E. Howell, seconded and carried unanimously that the retiring president, A. O. Backert, be elected to life honorary membership in the American Foundrymen's association. On motion made by J. P. Pero, Thomas Devlin was unanimously elected to honorary membership in the association.

The following papers and reports were read and discussed:

"The Economical Control and Handling of Patterns in a Large Foundry," by W. D. Jones, Canton Steel Foundry Co., Canton, O.

"Progress in the Application of Electric Arc Welding," by Robert E. Kinkead, Lincoln Electric Co., Cleveland.

"A New Cutting Gas," by Prof. Alfred S. Kinsey, Stevens Institute of Technology, Hoboken, N. J.

"Welding Castings of Different Metals and Different Sections," by George B. Malone, Bayonne Steel Casting Co., Bayonne, N. J.

Report of American Foundrymen's Association Committee on Promotion and Membership, by A. E. Howell, chairman, Nashville, Tenn.

"High Temperature Cement for Lining Cupolas, etc.," by W. S. Quigley, Quigley Furnace Specialties Co., New York.

Upon motion by R. A. Bull, it was unanimously decided to send the following communication to the United States senate committee on labor education, at that time engaged in investigating the steel strike:

COMMUNICATION TO SENATE COMMITTEE INVESTIGATING THE STEEL STRIKE FROM THE AMERICAN FOUNDRYMEN'S ASSOCIATION

The American Foundrymen's association is holding its annual meeting in Philadelphia. This convention is the greatest in our history of 24 years' advancement of the purely technical and industrial phases of the foundry industry. More than 3000 foundrymen are in attendance. Our exhibit of foundry equipment and supplies occupies the entire space of 90,000 square feet in the Commercial Museum. Unquestionably this meeting of foundry owners, managers, superintendents, chemists, foremen and of manufacturers of equipment required for foundry operation, embraces the most intelligent and broadminded personnel in the basic industry of casting of metals.

Never in the history of this organization have discussions been permitted in our meetings relating to the unionization of labor, or to advisable rates of wages. We contemplate no change in this policy and will continue to serve our industry in the future along the same scientific lines as in the past.

The operations of many industries have been affected by the present strike of steel workers instituted primarily against the United States Steel corporation. We recognize, as your investigating committee does, the tremendous importance of this strike. We believe the very bulwark of our nation is seriously menaced. We respectfully call to the attention of your committee the significant and incontrovertible fact that the vast majority of those who are attempting to paralyze the foundry industry coincident with the attacks upon the steel mills, are of foreign birth, and that whatever success in those endeavors is being achieved in our foundries results in very large degree from intimidation and violence.

You and your committee are charged with a solemn duty. We believe you will not shirk it, but will make your investigation rigorously searching, as to existing conditions of employment, and the present and past activities of the men who organized and are conducting the strike and of those opposed to them, to the end that in all branches of industry connected with the manufacture of iron and steel, those who work in them with their hands and brains may do so under conditions fair to both classes, in lasting security against improper coercion and in conformity with the principles of liberty drafted by our fathers in this city where our membership is now assembled.

This communication is without precedent in our organization. After mature deliberation we believe the circumstances justify it and that the essentially scientific nature of this the greatest organization of foundrymen in the world will give weight to our statements. We beg to inform you that a vast number of our members toiled with their hands for a daily wage in the earlier stages of their foundry careers. Hence our sympathies for the honest workingman are genuine.

The following resolutions, prepared by the committee on resolutions, were presented and unanimously adopted:

Philadelphia, Oct. 3, 1919.

Your committee has the pleasing privilege of undertaking to adequately express, if possible, the sentiments of the members of this association toward its host on this, its twenty-fourth annual meeting.

Today closes a convention most memorable in our history. The American Foundrymen's association first saw the light here in Philadelphia in 1896, and that kindly light has led us on through the years, and the wisdom of its founders has guided us and been ratified and verified by the vast strides that have been taken since that day.

Returning in 1907, and now again, in 1919, we find ourselves indebted in increasing measure to those men and those influences and that spirit of progress and generous hospitality, which launched our association into being.

It were difficult indeed in any reasonable space to enumerate all those to whom, for innumerable kindly activities, we are deeply grateful.

First shall come, however, the members of the Philadelphia Foundrymen's association, who collectively and through their officers, Thomas Devlin and Howard Evans, have left no stone unturned to make us feel that we have come truly to our old home and among those who take the keenest interest in the growth and progress of our association for whose beginning Philadelphia was so largely responsible.

To the various Philadelphia committees, who have responded so warmly—the clearing house committee, information committee reception and hotel committee, visitation of plants, publicity, finance, entertainment, golf and automobile committees, to each and all of them, their chairmen and members, we feel deeply grateful.

To Howard Bougher, of the committee of arrangements, and Frank Krug, of the committee on entertainment, we can hardly over-emphasize our appreciation.

One feature that made our coming to Philadelphia most practical was the Philadelphia Commercial Museum, where has been for the week the home of the great foundrymen's exhibit, occupying over 60,000 square feet, in the magnificent building and grounds in charge of Dr. W. P. Wilson, director, and C. D. Willison, superintendent. We feel particularly grateful to these gentlemen, as their activity and hearty co-operation made it possible for us to have this greatest of all exhibits.

Another outstanding event, which could not have happened anywhere except in Philadelphia, was the courtesy and very complimentary action of the American International Shipbuilding Corp. at Hog island, in naming the good ship AFOUNDRIA in honor of our association, and through President Matthew C. Brush the extending to our members every hospitality on the occasion of the launching and visitation of that marvellous place.

The record of our attendance, our sessions, our exhibits, the many forms of entertainment and hospitality has never been equaled, and it is difficult to conceive of its ever being surpassed.

To A. O. Backert, our retiring president, we extend our thanks for his ever diligent and efficient labor in our behalf both at home and abroad. To our European cousins in the iron and steel casting and metalworking industries he has carried the message of international friendship and goodwill. We feel sure the American Foundrymen's association and the industry at large in this country will for years profit from the favorable impression he created during

his visit in Great Britain and on the continent. In leaving this country he did not leave the interests of the American Foundrymen's association behind him. We have him to thank for the distinguished visitors from the other side who have been with us in the past week. It is with satisfaction that we regard the fact that while he retires as president, he remains as a counsellor of the association.

To C. E. Hoyt, our general manager and treasurer, we would also express thanks for the good generalship he has shown in the arrangement and management of the exhibit with its great multiplicity of details, greater than ever before. Equally efficient and satisfactory has been his conduct of the association's affairs during the year.

Others whom we desire to include in this appreciation are those who so ably presented papers of great interest and scientific value before the sessions of the convention.

While we are grateful to each, we must particularly emphasize our indebtedness to W. R. Bean, chairman of the papers committee, indefatigable in his zeal and interest, and to H. Cole Estep, secretary of that committee, who carried the very trying responsibility of "rounding up the whole." The innumerable details and continuous application necessary to get all into that printed form which will constitute one of our most notable volumes, is indeed a great work and too much honor cannot be accorded Mr. Estep and Mr. Bean.

We, THEREFORE MOVE, that the sincere appreciation and gratitude of the members of the association, severally and collectively, be extended to all those committees, industries and individuals that have studied ways to make us more happy, more comfortable and more successful and that manifold blessings rest with them all "till we meet again."

Upon motion of A. O. Backert, retiring president, it was voted unanimously to ratify all proceedings and acts of the convention before adjournment.

There being no further business, the meeting adjourned.

Annual Banquet

Thursday, Oct. 4, 7 p. m., Bellevue-Stratford Hotel

A. O. Backert, Cleveland, presided. Addresses were delivered by the following speakers:

Sir Ellis W. Hume-Williams, member of parliament, London, England; Dr. Marcel Knecht, member of French high commission; Maj. R. A. Bull, Duquesne Steel Foundry Co., Coraopolis, Pa.; and Hon. James M. Beck, former assistant attorney general of the United States.

Entertainment Features

Through the activity of local committees on arrangements, the members and guests of the association were offered numerous opportunities to enjoy the features of an unusually attractive entertainment program. The ex-officio members of these committees were Thomas Devlin and Howard Evans. Howard M. Bougher, chairman of the clearing house committee, and Frank Krug, head of the entertainment committee, were largely responsible for the courtesies extended to visiting foundrymen. On Tuesday those attending the convention enjoyed a boat ride on the Delaware river, the outstanding feature of which was the launching of the cargo carrier AFOUNDRIA by the American International Shipbuilding Corp., at Hog island. The ship, named in honor of the American Foundrymen's association and in recognition of the great work of the organization, was christened by Mrs. A. O. Backert. Wednesday morning the ladies were taken on an automobile trip through Fairmount park to Valley Forge where luncheon was served. In the afternoon a golf tournament was held at the Whitemarsh Golf club and in the evening members and guests enjoyed a theater party at Keith's. Thursday afternoon the ladies visited the plant of the Curtis Publishing Co., Wanamaker's store, Independence hall, and other points of interest. The annual banquet, mentioned above, was followed by dancing. During the convention many foundrymen visited the plants of the Baldwin Locomotive Works, Westinghouse Electric & Mfg. Co., and others in Philadelphia and vicinity.

Al Baekert

ADOLPHUS O. BACKERT

PRESIDENT AMERICAN FOUNDRYMEN'S ASSOCIATION, 1918-1919

Adolphus O. Backert, the twentieth president of the American Foundrymen's association, is a native of Cleveland and was educated at Western Reserve university of that city. After engaging in daily newspaper work in Cleveland for several years, he became identified with the business press through the Penton Publishing Co., and has been active in that field for 19 years. For six years he was located at Pittsburgh as representative of *The Iron Trade Review* and *The Foundry*. Subsequently he served for two years as western editor of the *Iron Age*. He became editor of *The Foundry* in 1907 and has served in that capacity ever since, and in connection, for several years, acted as engineering editor of *The Iron Trade Review*. At the present time in addition to being the editor of *The Foundry*, Mr. Backert is vice president and general manager of the Penton Publishing Co.

He has been very active in foundry organization work. Through his Pittsburgh residence, he was prominently identified with the Pittsburgh Foundrymen's association. He became secretary-treasurer of the American Foundrymen's association in 1914 and served continuously until his election as president in 1918. Mr. Backert organized and became secretary and treasurer, and later honorary member of the Foundry Supply Manufacturers' association. He also was secretary and treasurer of the Molding Machine Manufacturers' association until is was absorbed during the war by the Foundry Equipment Manufacturers' association, of which Mr. Backert is secretary-treasurer. He has contributed many papers to the American Foundrymen's association, particularly on molding machine practice and cost work. It was largely from his investigations and studies that the standard cost system for foundries now being widely adopted, was initiated. Mr. Backert conceived the Allied Metals congress which was held concurrently with the foundrymen's convention in Milwaukee in 1918. Early in 1919 he visited the principal foundry centers of Europe and personally invited foreign foundrymen to attend the Inter-Allied Foundrymen's convention and exhibition at Philadelphia. While in England Mr. Backert was the guest at dinners given by the British Foundrymen's association at Coventry and Sheffield. At Birmingham he was guest of honor at a dinner and meeting held under the auspices of the Birmingham branch of the British Foundrymen's association, the Birmingham Metallurgical society, the Birmingham section of the Institute of Metals and the Staffordshire Iron and Steel institute. While in Paris, he addressed the foundrymen and steel manufacturers of the Paris district at a dinner given in his honor.

Mr. Backert is a member of the American Society for Testing Materials, American Iron and Steel Institute, Iron and Steel Institute, American Institute of Mining and Metallurgical Engineers and Cleveland Engineering society. He became a honorary member of the American Foundrymen's association at the Philadelphia convention.

Transactions
of the
American Foundrymen's Association

Annual Address
By the President, A. O. Backert

FROM war to peace, from high pressure production for ordnance requirements to the uncertainty of demand for commercial needs, from the tense anxiety and excitement of a world conflict for the preservation of democracy to an unparalleled era of unbridled unrest, is the transition of the foundry industry in a period of 12 months. One year ago the manufacture of castings to comply with rigid government specifications and the quantity production of semisteel shells, were the important problems presented for the earnest consideration of foundrymen. Today's problems, cast up in the wake of the war, are equally important and equally urgent, and upon their solution depends the conversion of a glorious victory abroad to an assured peace at home.

As production and more production was the one essential to overwhelm the enemy, so increased production is needed today to restore the equilibrium of trade and industry. With the constantly growing shortage of labor and the decline in the manual output other means must be found to compensate for this deficiency in production. This situation has emphasized, more than ever before, the greater need of mechanical appliances in foundry operations and has been met by the installation of labor-saving equipment on a scale never before equalled in the history of the casting industry. Thus, by mechanical means will be solved the associated problems of labor shortage and lack of production in the foundry trade, as it will be solved also in every other industry.

Several months ago your president returned from an extended visit to England and France where he was afforded

unusual opportunities to study conditions prevailing in the foundry and iron and steel industries. The people of both countries then were still suffering from the tremendous shock of the war and the readjustment of their industrial activities to a normal status was beset with many difficulties and problems that seemed almost insurmountable. Their national debt, which exceeds per capita many times that of the United States and the depreciated value of their money as measured by the dollar standard are causes for great concern among manufacturers and financiers. Otherwise conditions generally are not unlike those confronting us today. To provide an income for the great army of workers precipitated out of employment with the sudden termination of the war, a scheme of out-of-work pay was resorted to in the United Kingdom. Originally intended as a temporary expedient to tide over these workers, it threatens to become a permanent bonus for idlness at a weekly cost to the government in excess of $5,000,000. During the months of May and June more than 1,000,000 men and women were given this support from the national treasury and notwithstanding the tremendous shortage of labor in the metal-working industries, the number obtaining government support is increasing rather than diminishing.

In the United Kingdom the demobilization of the army was speeded-up to a higher rate than in France. The return of millions of these men to peace-time pursuits, particularly those who have been out of touch with civil life for from four to five years involves difficulties that time alone can solve. In a comparatively limited degree, we too are familiar with the self-discipline involved in the transition of our soldiers from army to civil life and this, in only small measure conveys the situation existing in the United Kingdom and France.

Investigators Make Invidious Comparisons

It has been the prevailing practice of investigators of industrial conditions abroad to make invidious comparisons of production as compared with that of the United States. From the standpoint of tonnage and per capita output, particularly in the metal trades, these comparisons are borne out

by statistics. However, there must be some underlying reasons for the wide divergences in these figures and more than a cursory examination revealed the causes. It has been pointed out frequently that restraint of output is the brake upon all industry of the United Kingdom and that with its removal production could be speeded up to equal that of this country. Attention also has been directed to the lack of labor-saving equipment and the need of mechanical appliances to increase output.

A more than superficial investigation of the foundry industry of the United Kingdom discloses the effect of the restraint of output, which, however, was removed during the closing years of the war and has not again been invoked. Mechanical appliances are not in such widespread use in the casting industry as in this country. Yet many plants are modernly equipped throughout and their practice is equal to the best prevailing in the foundries of the United States. Then what are the underlying causes for the differences in the rates of production? Why is the tonnage per man for shops engaged in similar work so much greater here than in the United Kingdom?

Difference in Standard of Buyers

The wide divergence in the standards of the casting buyers of the two countries is one of the underlying reasons. The insistence upon high quality and superfine finish are two requirements that slow-up production abroad. The widespread use of dry sand molds in the United Kingdom and also in France, to provide the necessary finish demanded by the trade, is a large factor in reducing the per capita output. Quality and finish have been carried to the extreme and at the sacrifice of quantity. In the shops in this country, on the contrary, green sand practice prevails and quantity production is the goal to be attained, frequently at the expense of finish and quality. That a happy medium between the extremes of quality and quantity would serve the purpose cannot be denied, but years of education in one direction cannot be diverted to another course without an equal amount of training.

Repetition work in this country is one of the factors underlying large production and it lends itself admirably to the application of all kinds of mechanical and labor-saving devices. With us it is not unusual to make 50,000 castings from the same pattern and in the automobile trade this total frequently is exceeded. Dealing in large numbers of the same unit enables the American foundryman to equip for quantity production and he requisitions for his use the most modern mechanical devices available to increase output and reduce cost. In the United Kingdom and France, repetition work is not nearly so prevalent as in the shops of the United States. Quantity production of commodities is not appreciated in the same degree as over here, nor is the need for it nearly so great. Until this year quantity was not a great factor in the motor car industry abroad, and even today the largest output of the automobile plants of both of these countries is dwarfed by the annual production of many of our motor car manufacturers. Before the war, it has been stated that the total pleasure car needs of France was only 30,000 per annum. When this number is divided among many makers it becomes apparent that repetition work among French casting manufacturers cannot be developed to a very high degree.

Lack of Standardization

In addition, the lack of standardization in many of the engineering lines reduces repetition work to the minimum. Even the railroads are counted among the violators of standards in equipment and the whim of the designer too frequently is the altar upon which quantity production is sacrificed. It has been stated that manufacturers of sanitary ware in the United Kingdom have patterns in their vaults for several thousand different designs of bathtubs and it is not unusual for an architect to enhance the beauty of his creation by individually designed tubs. Thus, the lack of repetition work may be assigned to a multiplicity of orders for small numbers of castings from a variety of patterns and this plays havoc with production. Long runs from single patterns lead to production economies largely effected by the use of molding machines, whereas

small orders for castings from single models retard the installation of mechanical molding appliances, reduce the output and are a factor in maintaining the uneconomical practices of the jobbing shop.

To the comparative lack of repetition work in both the United Kingdom and France must be assigned the prevalence of the jobbing shop and the large number of small foundries, willing, even if not equipped for the production of castings in iron, brass or steel. However, this semijob work is not without its compensating features. It has a tendency to develop skilled molders, whereas our specialty shops train men to one operation, not one of whom could make a parting or cut a gate by hand. Yet notwithstanding these handicaps, the mechanical equipment of many of the foundries of the United Kingdom and France measure up to the best practice prevailing in this country. And the foundrymen of these countries are alive to the progress that is being made in casting manufacture over here. They are anxious to increase their production and to reduce their costs and to attain these ends they are preparing to install labor-saving equipment on an extensive scale.

Competition of Nationalities

Provided with the same machine on which similar patterns are mounted and operated under practically identical conditions, English foundrymen who have had opportunities to observe foundry practice in this country contend that we get the greater production. That restraint of output, operating for many years, has left its indelible mark upon their workingmen is apparent. Fortunately, in the United States there still prevails the competition of nationalities which is not a factor in England, Scotland, Ireland, Wales or France. Perhaps when we have centuries of tradition behind us, we too may suffer from the same lack of racial competition with which we are favored today.

Steel Casting Manufacture

Steel casting manufacture in the United Kingdom was greatly accelerated by the war. The output in 1918 totaled 276,518 tons, of which basic steel was only 10,564 tons as

compared with 265,954 tons of acid castings. This tremendous predominance of acid over basic steel, which is in striking contrast to the practice prevailing in this country, must be attributed, to a very large extent, to the insistence of the army and navy ordnance departments for castings made by the acid in preference to the basic process. The war also speeded the installation of electric furnaces for the production of steel for castings. At the time of the armistice, 37 were in operation in foundries with an actual output of more than 5000 tons per month and 11 additional were being installed which will increase the actual production to 7000 tons per month.

When the war was terminated, electric steel casting production was at its height in the United Kingdom, as indicated by the output of 46,637 tons in 1918 and compared with 108,296 tons for the United States in the same period. Of the total steel casting output of the United Kingdom in 1918, the electric process accounted for 17 per cent against 7.7 per cent for the United States, indicating a production in proportion to the total steel casting output more than twice as great as that of this counry.

Converter Process Predominates

A further analysis of the steel casting statistics for both countries in 1918 reveals striking differences in practice. Steel for casting purposes made in converters in the United Kingdom exceeded open-hearth production by 1936 tons, the former having totaled 116,231 tons against 113,630 tons for the latter. In the United States, on the contrary, where the open-hearth process predominates, the production of converter steel last year was 160,844 tons as compared with 1,140,830 tons of open-hearth steel. In the United Kingdom converter steel represents 42 per cent of the output as contrasted with 11.3 per cent in this country and open-hearth only 41 per cent against 80 per cent in the United States. Among the converter processes employed in the United Kingdom the Tropenas leads with 53,633 tons; the ordinary side-blow process is second with 48,858 tons and the Stock, oil-fired converter is third with 13,075 tons. Classified as

basic converter steel is 665 tons. No records are available of the production of steel castings by the crucible process in the United Kingdom and statistics of last year's output in the United States indicates also that this process is passing in this country. Statistics of the steel casting production of the United Kingdom and the United States for 1918, follow:

Analysis of Steel Casting Output, United Kingdom and United States, 1918

	United Kingdom Tons	United States Tons
Acid open-hearth	103,731	634,950
Basic open-hearth	9,899	505,880
Converter	116,231	160,844
Electric	46,657	108,296
Crucible	....	1,330
Miscellaneous	....	110
Total	276,518	1,411,410

In many of the English plants the combined installations of cupolas and converters are unique. For the purpose of eliminating the handling of the metal in ladles from the cupolas to the converters, the melting furnaces are located on platforms at a considerable height above the floor level to permit of tapping the iron direct from the cupola spout into the converters. Troughs are provided for directing the metal into the mouth of either converter, one being located on either side of the cupola.

Following the curtailment of ordnance buying and the cancellation of existing contracts in November last year, many electric furnaces in steel foundries were shut down and the production this year will show a material decline in the United Kingdom. This is due to the high cost of manufacturing this grade of steel and the comparatively limited demand for electric steel castings for commercial purposes.

British and French Foundrymen Extend Hospitalities

The generous hospitality and the many courtesies showered upon your executive while abroad by British and French foundrymen, were manifestations of the kindly feeling and love of the people of these two great nations for their American ally. Your president was asked to convey to you a message of

good-will from the casting manufacturers of the United Kingdom and France coupled with the hope that the bond of friendship cemented by the war, would never be broken. Your president was the guest of the Rover Co., Ltd., and the Daimler Co., Ltd., at a complimentary dinner in his honor at Coventry on April 30. Following the dinner he addressed a meeting of the members of the Coventry branch of the British Foundrymen's association. On Saturday, May 3, your president was the guest of the British Foundrymen's association and the Sheffield branch of this organization at a dinner at Sheffield, which was presided over by T. H. Firth, president of the national association. It was attended by the members of the council and prominent foundrymen and steel manufacturers of the Sheffield district. On Monday, May 5, your president was tendered a reception and dinner at Birmingham by the kindred Metallurgical associations of this great metal-working district. On this occasion it also was his privilege to deliver an address before the members of these societies at the Birmingham University.

Your president also had the privilege and honor to attend the first reception and dinner of the French Foundrymen's association since the beginning of the war in 1914. All meetings of this organization were postponed until after the enemy was vanquished and the gathering at Paris on May 24, was in the nature of a peace celebration coupled with the resumption of the normal functioning of this organization. On behalf of the American Foundrymen's association your president extended hearty invitations to the casting producers of the United Kingdom and France to attend this great convention and exhibit.

We have a large number of these visitors with us today, and we extend to them a hearty welcome. By their journey oversea they are helping to build a bridge of friendship, which forever should tie together the Allies of the Great War. Let us reciprocate in kind. This is the occasion for us to demonstrate to them our love and good-will and let it be so expressed that it will form the piers of that bridge of friendship that more than by any other means will give assurance for the peace of the world.

During the year your association established a home of its own in commodious offices in the city of Chicago. With a secretary and a competent organization that can devote all of its time and energy to association affairs, its accelerated growth and increased usefulness and influence is assured. While the membership has increased at a normal average rate during the year, the enrollment is representative of not more than 25 per cent of those entitled to affiliation with this society. It is fortunate that the foundrymen who constitute this minority so bravely accept the burden of the foundry trade of the North American continent to foster these great meetings and exhibitions. Let us hope that the overwhelming majority not now affiliated some day will see the light and will assume its share of the great responsibility of promoting the progress and advancement of the foundry industry of America.

For the success of this meeting and the wonderful display of labor-saving equipment in the Commercial Museum we are deeply indebted to our untiring secretary and his corps of assistants. Throughout the year he has lightened the duties of my office in every possible way and to him and to the directors, committee members and others who have given so freely of their time and energy for the growth of this association, I wish to express my warm appreciation and hearty thanks. Never was man privileged to work with a better, more earnest or congenial crowd.

Before closing I wish to recall to you the great loss which our organization sustained in the death of Major Jos. T. Speer, on Jan. 5, this year. Since his affiliation with us many years ago, no task was too great and no duty too trivial, which he did not perform cheerfully and well in our behalf. His ability and devotion were recognized by his election to the presidency for two terms in 1912 and 1913, and since that time he served as a member of our board of directors until failing health caused him to decline re-election. Appropriate resolutions already have been adopted by the board of directors and I suggest that we rise and pay silent tribute to his memory.

Annual Report of the Board of Directors

To the Members of the American Foundrymen's Association, Inc.:

Two meetings of the Board of Directors of the American Foundrymen's Association, Inc., were held during the fiscal year, one at Milwaukee, Oct. 9, 1918, and the other at Philadelphia, Pa., Feb. 7, 1919.

At the Milwaukee meeting the board organized and elected officers. They also passed an amendment to the By-laws increasing active member dues from $10 to $12, and associate member dues from $5 to $6. At this meeting it was decided to postpone the transfer of the properties and business affairs to the newly elected Secretary-Treasurer until the next meeting of the Board of Directors.

At the Philadelphia meeting, Feb. 7, 1919, the first order of business was the appointment of a committee by President Backert, consisting of Messrs. Howell, Pero and Minich, to draft suitable resolutions on the death of former president, Major Joseph T. Speer, who died at his home in Pittsburgh, Jan. 5, 1919. These resolutions, presented later in the day, were adopted by a rising vote and ordered spread upon the records, and are contained in full in the minutes of that meeting.

A special committee was also appointed by the President to draft a telegram to be sent by the Board of Directors to former President Major R. A. Bull, who had on the day previous returned from service in France.

The report of the 1918 Committee on Exhibits was received and it was decided to set aside the sum of $5000 out of the earnings of the Department of Exhibits for the year 1918, as a reserve fund, to transfer $1000 from the Department of Exhibits to the Technical Department, and to pay to the Institute of Metals Division of the American Institute of

Mining and Metallurgical Engineers, the sum of $250, from the funds of the Department of Exhibits.

On April 7, 1919, Mr. H. E. Diller tendered his resignation as a director of the association, and in doing so stated that he considered his election as due to his position with the General Electric Co., and now that he was no longer with that company, but with one which was already represented on the Board of Directors, he desired to tender his resignation. This was reluctantly accepted by President Backert, who, to fill the vacancy, appointed Lieut. S. Griswold Flagg III, who had resigned as vice president and director of the association during 1917, having been commissioned as naval constructor, with rank of lieutenant, senior grade, U. S. N. R. F.

One meeting of the 1918 Exhibition Committee was held at Philadelphia, Feb. 7, 1919. At this time the report of C. E. Hoyt, exhibition manager in charge of the Milwaukee exhibit, was received.

One meeting of the 1919 Exhibition Committee was held during the fiscal year, at Cleveland, May 13, 1919, at which time preparations were made for the exhibit to be held in Philadelphia the week of Sept. 29.

The reports of the various meetings of the Board of Directors, Exhibit Committee meetings, etc., are appended hereto.

Respectfully submitted,
C. E. HOYT, *Secretary-Treasurer.*

Minutes of Meetings of Board of Directors

Annual Meeting of the Board of Directors of the American Foundrymen's Association, Inc., Held at the Milwaukee Auditorium, Milwaukee, Monday, Oct. 7, 1918.

Pursuant to a call for the annual meeting of the Board of Directors of the American Foundrymen's Association, Inc., issued by President B. D. Fuller, a meeting of the board was held at the Milwaukee Auditorium, Milwaukee, at noon, Monday, Oct. 7, 1918. However, in the absence of a quorum, President Fuller adjourned the meeting to the evening of the seventh, at the Milwaukee Athletic club.

Benj. D. Fuller, *President.*
A. O. Backert, *Secretary.*

Annual Meeting of the Board of Directors of the American Foundrymen's Association, Inc., Held at Milwaukee Athletic Club, Milwaukee, Monday Evening, Oct. 7, 1918.

The adjourned meeting of the Board of Directors of the American Foundrymen's Association called for noon, Monday, Oct. 7, was held at the Milwaukee Athletic Club, Milwaukee, Monday Evening, Oct. 7, 1918.

The following were in attendance:

H. R. Atwater, Cleveland Osborn Mfg. Co., Cleveland.
A. O. Backert, The Penton Publishing Co., Cleveland.
H. E. Diller, General Electric Co., Erie, Pa.
A. E. Howell, Phillips & Buttorff Mfg Co., Nashville, Tenn.
C. E. Hoyt, Chicago.
W. A. Janssen, Canadian Steel Foundries, Ltd., Montreal.
S. T. Johnston, S. Obermayer Co., Chicago.
V. E. Minich, Sand Mixing Machine Co., New York.

C. E. Hoyt discussed the work of the War Service Committee at Washington, which subsequently will take the form of a written report and which will be included in the bound volumes of the Transactions.

B. D. Fuller, President, who is a member of the Committee on Iron and Steel Scrap of the American Iron and Steel Institute, also reported briefly on the year's activities.

The Secretary, A. O. Backert, presented letters received from E. N. Hurley, president of the United States Shipping Board, recommending the appointment of a committee on merchant marine and this was unanimously favored by all of the directors present. It was suggested that the appointment of such committees by the association be considered and recommendations urging the drafting of resolutions by the separate bodies also were made. It also was the concensus of opinion that a resolution be sent to the President of the United States, by the conventions, demanding

the immediate and abject surrender of the enemy. A committee consisting of Messrs. Howell, Minich and Backert was appointed by President Fuller to draft such a resolution.

C. E. Hoyt directed attention to valuable services rendered by Emlyn Thomas, assistant to the secretary, who has been employed by the association at a salary of only $50 per month by the technical department and $25 per month by the Exhibition Department. Mr. Hoyt was of the opinion that Mr. Thomas should receive additional compensation for his services and he proposed that Mr. Thomas be paid the sum of $300 as additional compensation for his valuable services so faithfully and loyally rendered. It also was recommended by Mr. Hoyt that this sum be charged against the Exhibition account. This motion was seconded by V. E. Minich and carried unanimously.

The secretary then presented the resignation received from Stanley G. Flagg III, which had been accepted by the president shortly after its receipt. A. E. Howell, on behalf of the Board of Directors requested that Lieutenant Flagg's resignation be received with an expression of keen regret but at the same time he is to be applauded for his great devotion to his country in a time when his services are greatly needed. Mr. Howell's motion was seconded by S. T. Johnston and the resignation of Lieutenant Flagg as vice president was accepted by the Board, this action being in the form of a ratification of the action taken by President Fuller earlier in the summer.

C. E. Hoyt, Exhibition Manager, presented a report on the exhibition in which he approximated the number of exhibitors, gate receipts for the first day, etc. Mr. Hoyt pointed out that upon the advice of the president and secretary it was decided not to make any change in the admission charge but to deduct the war tax from the gate receipt. It also was decided to continue the policy of admitting ladies free to the exhibition. This action of the officers was ratified by the Board upon motion by W. A. Janssen which was seconded by H. E. Diller.

The President announced that a meeting of the newly elected Board of Directors would be held at noon, Wednesday, Oct. 9, in the Board of Directors' room of the Milwaukee Auditorium.

There being no further business the meeting adjourned.

BENJ. D. FULLER, *President*
A. O. BACKERT, *Secretary.*

MEETING OF THE BOARD OF DIRECTORS OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION, HELD IN THE BOARD OF DIRECTOR'S ROOM, MILWAUKEE AUDITORIUM, MILWAUKEE, WEDNESDAY, AFTERNOON, OCT. 9, 1918.

Following the session of the annual meeting of the members of the American Foundrymen's Association, Inc., held Wednesday morning, Oct. 9, at which the members of the Board of Directors were elected, a meeting of this Board was held in the Board of Director's room of the Milwaukee Auditorium in the afternoon of this day for the purpose of electing officers and transacting such other business as might be presented.

At the session of the annual meeting held Wednesday morning,

Oct. 9, the following were elected members of the Board of Directors of the American Foundrymen's Association:

H. R. Atwater, Cleveland Osborn Mfg. Co., Cleveland.
A. O. Backert, The Penton Publishing Co., Cleveland.
W. R. Bean, Naugatuck Malleable Iron Works, Naugatuck, Conn.
R. A. Bull, Duquesne Steel Foundry Co., Pittsburgh.
H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I.
H. E. Diller, General Electric Co., Erie, Pa.
A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
C. E. Hoyt, Chicago.
W. A. Janssen, Canadian Steel Foundries, Ltd., Montreal.
S. T. Johnston, S. Obermayer Co., Chicago.
C. S. Koch, Fort Pitt Steel Casting Co., McKeesport, Pa.
W. G. Kranz, National Malleable Castings Co., Cleveland.
V. E. Minich, Sand Mixing Machine Co., New York.
C. R. Messinger, Chain Belt Co., Milwaukee.
J. P. Pero, Missouri Malleable Iron Co., East St. Louis, Ill.
H. B. Swan, Cadillac Motor Car Co., Detroit.

The following members of the Board were in attendance:

V. E. Minich, A. E. Howell, S. T. Johnston, H. B. Swan, C. R. Messinger, H. R. Atwater, C. E. Hoyt, W. A. Janssen, A. O. Backert and C. S. Koch.

For the purpose of effecting an organization, retiring President B. D. Fuller was selected chairman.

Nominations for the office of president of the American Foundrymen's Association were called for and A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn., nominated A. O. Backert, The Penton Publishing Co., Cleveland, for this office. After having been seconded a motion was made that nominations be closed.

Nominations for the office of vice president of the American Foundrymen's Association then were called for. It was decided to ballot and after a number of ballots, W. A. Janssen, Canadian Steel Foundries, Montreal, received a majority and it was decided to make his nomination unanimous, which carried without dissent.

Nominations for the office of secretary and treasurer then were called for and a motion was made by W. A. Janssen and seconded by S. T. Johnston, that the office of secretary and treasurer be combined. This motion prevailed unanimously. Upon motion which was duly seconded, C. E. Hoyt, exhibition manager, was nominated for this office. It was then moved and seconded that nominations be closed.

Following the selection of the above named gentlemen for the offices of President, Vice President and Secretary-Treasurer, and at the request of the Secretary, the ballot was unanimously cast by A. E. Howell. The officers of the American Foundrymen's Association, Inc., for the year 1918-1919, as elected, follow:

President—A. O. Backert, The Penton Publishing Co., Cleveland.
Vice President—W. A. Janssen, Canadian Steel Foundries, Montreal.
Secretary-Treasurer—C. E. Hoyt, Chicago.

It was suggested that an executive committee of the Board of Directors be appointed to transact business in the interim between

meetings of the Directors of the American Foundrymen's Association. Motion was made by A. E. Howell and seconded by C. R. Messinger, that a committee of five (5) be appointed to consist of the three (3) officers of the Association and two (2) other members of the Board to be appointed by the President. After a brief discussion, this motion prevailed without dissent.

The retiring secretary, A. O. Backert, then directed attention to the increased cost of operating the Association and conducting the affairs and recommended that the dues of both active and as-associate members be increased. Following discussion Mr. A. E. Howell offered the following amendment to the By-laws of the American Foundrymen's Association, Inc.:

Resolved, That Article 7, Section 1 be amended to read as follows:

"The entrance fee for active members shall be $10.00, which must be submitted with the application. Dues for Active members shall be $12.00 per annum."

And that Article 7, Section 2 be amended to read:

"The entrance fee for Associate members shall be $5.00 which must be submitted with application. Dues for Associate members shall be $6.00 per annum."

The question of the transfer of the property of the Association from the retiring Secretary-Treasurer, A. O. Backert, to the newly elected Secretary-Treasurer, C. E. Hoyt, was then discussed at length. It was pointed out that C. E. Hoyt in his capacity as exhibition manager, would be busily engaged with the work of winding up the affairs of the Milwaukee exhibition for several months and it was suggested that all matters relating to the salaries of the retiring Secretary-Treasurer for the interim pending transfer of the properties and business affairs to the newly-elected Secretary-Treasurer, be held in abeyance until the next meeting of the Board of Directors. Mr. Howell's recommendation was made in the form of a motion and having been seconded it was the unanimous expression of the members of the Board that these matters be held in abeyance until the next meeting of the Board of Directors.

There being no further business, the meeting was adjourned.

Benj. D. Fuller, *President.*
A. O. Backert, *Secretary.*

Minutes of Meeting of Board of Directors of the American Foundrymen's Association, Inc., Held at Bellevue-Stratford Hotel, Philadelphia, Pa., Friday, Feb. 7, 1919.

The meeting was called to order by President A. O. Backert in the chair, and the following directors were present:

A. O. Backert, Penton Publishing Co., Cleveland, O.
W. A. Janssen, Canadian Steel Foundries, Montreal.
C. E. Hoyt, Chicago.
H. R. Atwater, Cleveland-Osborn Mfg. Co., Cleveland, O.
W. R. Bean, Eastern Malleable Iron Works, Naugatuck, Conn.
H. A. Carpenter, General Fire Extinguisher Co., Providence, R. I.
H. E. Diller, Penton Publishing Co., Cleveland, O.

A. E. Howell, Phillips & Buttorff Mfg. Co., Nashville, Tenn.
S. T. Johnston, S. Obermayer Co., Chicago.
C. R. Messinger, Sivyer Steel Casting Co., Milwaukee, Wis.
V. E. Minich, Sand Mixing Machine Co., New York City.
J. P. Pero, Missouri Malleable Iron Co., E. St. Louis, Ill.
H. B. Swan, Cadillac Motor Car Co., Detroit, Mich.

Minutes of the meeting of the special committee in Milwaukee, February 25 and 26, 1918, were read and approved.

Minutes of the annual meeting of the Board of Directors held at noon Monday, Oct. 7, 1918, at Milwaukee, minutes of the adjourned annual meeting held at the Milwaukee Athletic club the evening of Oct. 7, 1918, and the minutes of the meeting of the Board of Directors held in Milwaukee, Wednesday afternoon, Oct. 9, 1918, were all read and approved as read.

A committee was appointed by the President, consisting of Messrs. Howell, Pero and Minich, to draw up suitable resolutions on the death of former president, Major Joseph T. Speer.

A committee was appointed by the President, consisting of Messrs. Carpenter and Pero, to draw up a telegram to be sent by the Board of Directors, to former president Major R. A. Bull, who had, on the day previous, returned from France.

The President declared that the meeting of the Board of Directors would stand adjourned to be called later in the day, following the meeting of the Exhibition Committee.

A. O. Backert, *Chairman.*
C. E. Hoyt, *Secretary.*

Minutes of Adjourned Meeting of Board of Directors of American Foundrymen's Association, Inc., Bellevue-Stratford Hotel, Philadelphia, Pa., Friday, Feb. 7, 1919.

Meeting called to order by President Backert in the chair. All of the directors present at the morning meeting were present at the adjourned meeting, and were joined by Mr. C. S. Koch.

The Secretary read the following as recommendations by the Exhibit Committee to the Board of Directors:

First.—That the sum of $5000 be set aside as a reserve fund, out of the earnings of the 1918 Exhibit.

Second.—That the exhibits be open one night each year.

Third.—That the sum of $1000 be paid to the Technical Department of the American Foundrymen's Association, Inc., out of the earnings of the 1918 exhibit.

Fourth.—That the sum of $250 be paid to the Institute of Metals Division of the American Institute of Mining Engineers, out of the earnings of the 1918 exhibit.

Moved by Mr. Janssen and second by Mr. Messinger that the recommendations of the retiring exhibit committee be accepted and adopted. Carried.

President Backert then submitted the following report covering cash and material turned over by the retiring Secretary, A. O Backert, to the new Secretary, C. E. Hoyt.

Money—

Central National Bank, Technical Account	$ 2,859.04
Superior Savings & Trust Co., Exhibition Account	11,481.31
Superior Savings & Trust Co., Cost-Keeping	1,688.33
Superior Savings & Trust Co., Research Fund	357.71
	$16,386.39

Materials—

1 Model 5 Underwood Typewriter
2 letter filing cabinets.
1 pamphlet filing case.
1 4-drawer filing cabinet.
1 sectional bookcase, 5 tiers.
1 steamer trunk.
213 bound volumes of Transactions A. F. A.
Membership Record Cards, record books, bank books, check books and supplies, including copies of cost bulletins, year books, pamphlets, etc.

The statement was made that at the annual meeting of the Board of Directors held in Milwaukee, Oct. 9, 1918, when the officers for the ensuing year were elected, it was moved that all matters pertaining to salaries be held in abeyance until a future meeting of the Board of Directors, to be held after the newly elected Secretary had completed his work on the 1918 exhibit, and a transfer of the work of the Secretary's office had been made from Cleveland to Chicago.

Following this statement it was moved by Mr. Minich and seconded by Mr. Carpenter, that due to the large amount of work in transferring the office of the secretary, the salary of the former secretary be continued until March 1, at which time it was anticipated that all transfers would be completed. Motion prevailed.

The question of the salary of the Secretary-Treasurer was then taken up, and it was moved by Mr. Messinger and seconded by Mr. Howell, that the salary of C. E. Hoyt as Secretary-Treasurer of the American Foundrymen's Association, Inc., dating from Dec. 15, 1918, should be $150 per month. Moved by Mr. Messinger and seconded by Mr. Howell, that the salary of C. E. Hoyt as Manager of the Department of Exhibits of the American Foundrymen's Association, Inc., dating from December 15, 1918, be $500 per month. Motions prevailed.

Moved by Mr. Howell and seconded by Mr. Swan, that the President and Secretary be authorized to secure an editorial assistant who would be secretary of the Committee on Papers, at a salary not to exceed $1200 per annum. Motion prevailed.

At this point Mr. Pero read a draft of the telegram to be sent to former President Major R. A. Bull, which was adopted by a rising vote and ordered made a part of the records.

"The Board of Directors of the American Foundrymen's Association are in session. The first matter of business was to appoint a committee to extend to you a welcome home. We are overjoyed and wish you had been able to meet with us. We are proud of you and the distinction you have attained. At one o'clock we will think of you and Mrs. Bull, raise our glasses and drink your heath and wish you all that cheero implies. This has been read and unanimously ratified.

"Carpenter and Pero."

Following the reading of the telegram the meeting recessed for luncheon.

After luncheon the committee appointed to audit the report of the Manager of Exhibits, reported that they had gone over the auditor's statement and itemized statement attached, and found same correct. Moved and carried that the report of the committee be accepted.

The report of the committee on the resolutions on the death of former president, Major Joseph T. Speer, was read and adopted by a rising vote.

"On January 5, 1919, the American Foundrymen's Association lost Major Joseph T. Speer. Major Speer became attached to the association in 1909 and was promptly recognized as a spirit destined to lead in the Association's activities. He was made vice president in that year and was president at the Pittsburgh and Buffalo meetings, and at the latter was elected an honorary life member.

"Major Speer was a member of the committee that was charged with the guiding of the Association through its transition period, when being reconstructed to a chartered corporation. He was unremitting in his zeal and loyalty to the best interests of the Association. He was always hearty, sometimes bluff because frank and vigorous in action, but no one who knew Major Speer, but knew that very close to the surface was a heart as tender as a woman's, a dauntless courage of conviction, and a devotion as true as the magnetic needle.

"A distinguished success in his own business, he brought to our Association ripe counsel, and a broad acquaintance with men and affairs touching our Association's interests. Our Association will continue to progress on the foundation to which Major Speer potently contributed; but those with whom he mingled, and who came under the charm of his intimacy and friendship, can never forget him, nor lose their appreciation of his services to the American Foundrymen's Association.

"Because of our love and appreciation, we wish this tribute of him recorded on the minutes of the Board of Directors, and a copy transmitted to his family.

"'May he live again, in minds made better by his
presence; live
In pulses stirred to generosity,
In deeds of daring rectitude, in scorn
For miserable aims that end with self;
In thoughts sublime that pierce the night like stars,
And with their mild persistence urge men's search
To vaster issues.'"

Very respectfully,
J. P. Pero,
V. E. Minich,
Alfred E. Howell.

New Business.—The questions of increasing the membership and the good of the Association were then discussed, and it was decided that a new committee should be added to the list of committees to be appointed, to be known as the Committee on Promotion and Membership.

The President then announced that the 1919 Exhibit committee should consist of the following:

A. O. Backert, Chairman; W. A. Janssen, H. R. Atwater, A. E. Howell, S. T. Johnston, G. S. Koch and V. E Minich.

The chair then announced that we would proceed to consider the invitations for the 1919 meeting, stating that a special committee consisting of the President, the Secretary, and Messrs. Atwater, Johnston and Minich, had visited Rochester on Wednesday, Feb. 5, where they were cordially received and entertained by a delegation of foundrymen and business men, had inspected the hotels, exhibition buildings, and available meeting places and found them acceptable in every way. That the committee had met in Philadelphia on Thursday, Feb. 6, had met a representative of the Chamber of Commerce, and the manager of the Hotel Men's Association, and had been taken by them to the Commercial Museum, were shown the building that was available for exhibit purposes, which was found adequate, and were also assured that the necessary arrangements could be made for meeting places. The committee were also furnished with a list of Philadelphia hotels and rates.

Later, on the same day, the committee received a delegation from Atlantic City, consisting of Mr. A. T. Bell, Chairman of the Hotel Men's Association, and Mr. Stine, Secretary-director of the Publicity Bureau. (Mr. Hill, Manager of the Million Dollar Pier) had met some of the committee earlier in the day. These gentlemen extended a cordial invitation to the Association to meet in Atlantic City, and submitted a written proposition for our consideration and acceptance if found satisfactory.

Following this report considerable discussion was indulged in, during which time it developed that Atlantic City, because of its lack of exhibition facilities for an exhibit such as ours, could not be considered.

The Directors waited until four o'clock for Director Wilson of the Commercial Museum to report with a definite proposition, and on his failing to be there at that time, it was moved by Mr. Howell and seconded by Mr. Pero, that a committee consisting of President Backert, Secretary Hoyt and Messrs. Johnston, Atwater and Minich be authorized to investigate further, and empowered to decide on the place and time for the 1919 meeting.

On motion the meeting adjourned.

A. O. Backert, *Chairman.*
C. E. Hoyt, *Secretary.*

Annual Meeting of the Board of Directors of the American Foundrymen's Association, Inc., the Philadelphia Commercial Museum, Philadelphia, Sept. 28, 1919.

Pursuant to a call for the annual meeting of the board of directors of the American Foundrymen's Association, Inc., issued by President A. O. Backert, a meeting was held at the temporary office of the secretary in the Commercial Museum, Philadelphia, at noon, Monday, Sept. 29, 1919. There being no quorum present the meeting was adjourned until Tuesday evening, Sept. 30, at the Union League club, of Philadelphia.

A. O Backert, President,
C. E. Hoyt, Secretary.

Annual Meeting of the Board of Directors of the American Foundrymen's Association, Inc., the Union League Club, of Philadelphia, Sept. 30, 1919.

The adjourned meeting of the board of directors of the American Foundrymen's Association, Inc., called for noon, Monday, Sept. 29, was held at the Union League club, of Philadelphia, Tuesday evening, Sept. 30, 1919.

The following directors were in attendance: A. O. Backert, president; H. R. Atwater, W. R. Bean, R A. Bull, Henry A. Carpenter, S. G. Flagg, III., Alfred E. Howell, C. E. Hoyt, W. A. Janssen, S. T. Johnston, C. S Koch, C. R. Messinger, V. E. Minich, J. P. Pero.

This meeting was also the occasion of the annual alumni dinner to which all past presidents and officers of the association, members of the advisory board, were invited and the following met with the directors:

John A. Penton	Secretary, 1896-1899
Dr. Richard Moldenke	Secretary, 1900-1914
S. G. Flagg, Jr	President, 1908
Arthur T. Waterfall	President, 1910
B. D. Fuller	President, 1918
H. Cole Estep	Secretary of the Papers Committee

Letters were received from W A. Jones, president, 1901; L. L. Anthes, president, 1909; and H. D. Miles, president. 1913, expressing their regret at not being able to attend. All present were guests at dinner of Stanley G. Flagg, Jr., and S. Griswold Flagg, III.

Following the dinner President A. O. Backert opened the meeting by briefly reviewing the work and growth of the association and called attention to the special features of the program for convention week. He also called attention to the correspondence received from the American Society for Testing Materials on the question of the "Standardization of Pattern Colors, Core Prints, Shrinkage, Etc." No action was taken but it was understood that the president would continue to co-operate with the A. S. T M. until a committee was formed along the lines suggested by the A. S. T. M.

A communication was also read on the subject of the ways and means committee bill known as H. R. 5941, which was a proposed "Tariff Plumbago Graphite and Silver Lead." On motion it was ordered that the communication be filed.

The president then called on the secretary for an informal report on association matters.

The secretary reported that since July 1, at which time the book membership of the association was 1103, approximately 180 new members had been obtained as a result of the activities of the membership committee, and that during the same period, approximately 60 resignations had been received, leaving the total book membership something over 1200, of which total a little over 100 were associate members.

For the department of exhibits, the secretary reported 214 exhibitors using over 60,000 square feet of space; a comparison with past years showed that the 1919 exhibit was the largest, in point of num-

bers and square feet of space used, in the history of the association. Attention was also called to the fact that while there had been no increase in the cost of space, the cost of installation would be a great deal more, and that the item of power alone would exceed by several thousand dollars the cost of power at any previous exhibit.

President Backert, commenting on the absence of J. S Seaman, the oldest living past president of the association, said that Mr. Seaman had hoped to attend the meeting but on account of the illness and death of his son, felt unable to do so. It was moved by Mr. Howell and seconded by Mr. Waterfall that a committee be appointed to wire a message of greetings and condolence to Daddy Seaman. Major R. A. Bull and the secretary were named. The message follows:

"The directors, honorary members, and officers of the American Foundrymen's association, in annual meeting assembled, wish to convey to you the warm greetings of the association, whose members are privileged to call you Daddy. We deeply deplore your absence and mourn with you in your present sorrow. This message, inspired by enduring affection, is sent in the hope that it may lighten your sadness of heart and comfort you through the sincere sympathy of loving friends.

"Backert, Janssen, Hoyt, Pero, Howell, Fuller, Waterfall, Flagg Senior, Flagg Third, Swan, Estep, Bean, Johnston, Atwater, Minich, Koch, Messinger, Moldenke, Penton, Carpenter, and Bull."

The president then called on the "old timers" present for remarks, and A. E. Howell, 1914, and J. P. Pero, 1917, made interesting comments on the work of the association past, present and future.

Dr. Richard Moldenke followed with a very interesting talk making comparison with the earlier days when the responsibilities of the association devolved very largely on the shoulders of one individual, and the present day, when the association enjoys the benefit of a very active board of directors and splendid committees.

Major R. A. Bull, whose duties with the American Expeditionary Forces in France made it impossible for him to attend the last annual meeting, gave a very interesting talk on his experiences "over there," and expressed his views on social and industrial conditions in France as observed by him.

Stanley G. Flagg Jr., the oldest past president present, like Dr. Moldenke, compared the association of the present with the days when he was president when the association had a membership less than half its present size.

John A. Penton, the first secretary of the association and the one who was largely responsible for its organization, briefly reviewed the history of the association from the time of the first meeting to date, and prophesied a great future for the organization. Mr. Penton closed his remarks by making an offer to give an annual award or trophy to be awarded to the person who made the most noteworthy contribution for the advancement of the foundry industry during the year. Alfred E. Howell expressed for the officers and directors their appreciation of Mr. Penton's offer, and moved a vote of thanks, and the appointment of a committee of five, by the president, to confer with Mr. Penton as to the details of his offer. The motion prevailed unanimously.

There being no further business, the meeting stood adjourned.

A. O. Backert, President
C. E. Hoyt, Secretary.

Minutes of the Meetings of the Exhibition Committee

Minutes of Meeting of the 1918 Committee on Exhibits, Bellevue-Stratford Hotel, Philadelphia, Pa., Friday, Feb. 7, 1919.

The meeting was called to order by President Backert in the chair.

Present: A. O. Backer, H. R. Atwater, Henry A. Carpenter, Alfred E. Howell, S. T. Johnston, V. E. Minich, H. B. Swan and C E. Hoyt.

Directors W. A. Janssen, W. R. Bean, H. E. Diller, C. R. Messinger and J. P. Pero, were requested by the President to meet with the committee, and did so.

The President called for the report of the Manager of Exhibits, and Secretary Hoyt read his annual report as Manager of the exhibit held in Milwaukee, Oct. 7 to 12, 1918. This report is appended hereto.

Moved by Mr. Howell and seconded by Mr. Minich that the report be accepted and filed. Carried.

Moved by Mr. Howell and seconded by Mr. Johnston, that a committee of three be appointed to audit the report of the Manager of Exhibits. The chair appointed Messrs. Janssen, Atwater and Messinger.

The committee then proceeded to consider the recommendations made by the Manager of Exhibits.

It was moved by Mr. Howell and seconded by Mr. Johnston, that we recommend to the Board of Directors, that the sum of $5000 be set aside as a reserve or emergency fund, out of the earnings of the 1918 exhibit. Motion carried unanimously.

Moved by Mr. Johnston and second by Mr. Atwater, that we recommend to the Board of Directors that the sum of $1000 be paid to the Technical Department of the American Foundrymen's Association, Inc., out of the earnings of the 1918 Exhibit. Motion prevailed.

Moved by Mr. Johnston and seconded by Mr. Atwater, that we recommend to the Board of Directors that the sum of $250 be paid to the Metal Division of the American Institute of Mining Engineers, out of the earnings of the 1918 exhibit. Motion prevailed.

Moved by Mr. Minich and seconded by Mr. Atwater that we recommend to the Board of Directors that the exhibit be open one night each year. Motion prevailed.

Moved by Mr. Swan, seconded by Mr. Minich, that the meeting of the Exhibit Committee stand adjourned.

A. O. Backert, *Chairman*.

C. E. Hoyt, *Secretary*.

MINUTES OF THE FIRST MEETING OF THE 1919 COMMITTEE ON EXHIBITS, HELD AT THE HOTEL STATLER, CLEVELAND, TUESDAY, MAY 13, 1919.

Present—Vice President W. A. Janssen, Alfred E. Howell, H. R. Atwater, S. T. Johnston, V. E. Minich and C. E. Hoyt.

In the absence of President A. O. Backert, Chairman of the Committee, Vice President W. A. Janssen presided.

The Secretary made a statement as to the situation relative to a lease of Exhibition Hall of the Commercial Museum, and the power to be made available by the Philadelphia Electric Co. The Secretary reported that while he had had much correspondence with the Philadelphia local committee, the director of the Commercial Museum, and Mr. Fisher of the Philadelphia Chamber of Commerce, a copy of the lease which was to be submitted to the Philadelphia Council, for approval, had not been furnished. It was pretty generally understood, however, that the terms of the lease would be as follows:

The nominal charge of $1 would be made.

The Association would be responsible for all expenses, including insurance, heat, light, janitor service, special watchmen and police, and would make good all damages of whatsoever character, done to the building and the premises during the period of occupation.

That the Association would have the privilege of cutting through the floor for foundations and pits, and doing whatever is customary at the annual exhibit.

That all the electrical installation in the building, aside from temporary connection of motors, is to be of a permanent character, approved by the Museum and City authorities, and remain the property of the Museum.

The Secretary also reported progress made in securing exhibits and stated that without doubt this would be the largest exhibit ever held.

The question of advertising was discussed, and the plan most favored was that of a series of letters addressed to foundries and individuals in the foundry field, setting forth the advantages and importance of attending the convention and exhibit. In this connection it was moved by Mr. S. T. Johnston and seconded by Mr. V. E. Minich, that the Exhibit Committee authorize the appropriation of certain necessary funds from the Department of Exhibits account, to be used to defray the expense of the proposed campaign by the Committee on Promotion and Membership, same to be charged to advertising.

The Secretary read the draft of Rules and Regulations governing the Philadelphia Exhibit, and these were approved paragraph by paragraph, the only changes of importance being to hold the exhibit open on Tuesday evening, Sept. 30, from 7 to 10 o'clock, and to close on all other days at 5 p. m.

The Secretary suggested that the exhibit be continued through Saturday, Oct. 4, but this was unanimously disapproved by the Committee.

Respectfully submitted,

C. E. HOYT, *Secretary*.

Annual Report of the Manager of Exhibits

Chicago, Feb. 7, 1919.

To the Committee on Exhibits, American Foundrymen's Association, Inc.

I am pleased to submit the following as a report covering the third annual exhibit held under the auspices of the American Foundrymen's Association, Incorporated, and the thirteenth held in conjunction with the annual meetings of the Association.

At the meeting of the Board of Directors held in Pittsburgh, Feb. 16, 1918, a special committee consisting of President B. D. Fuller, Vice President Stanley G. Flagg, Secretary A. O. Backert, H. R. Atwater, S. T. Johnston, V. E. Minich and C. E. Hoyt, were appointed to select the place for the 1918 Convention and Exhibit. This entire committee with the exception of Mr. Stanley G. Flagg, met in Milwaukee, Feb. 25 and 26, and after a conference with the local interests, and due consideration of their proposition, selected that city as the place of the 1918 meeting.

The exhibit was held in the Auditorium at Milwaukee, Oct. 7 to 12, 1918. The building was well suited to our requirements, having splendid accommodations for the meetings of the Association as well as for the exhibits.

Number of Exhibits.—A total of 198 firms paid the annual exhibitor's permit fee, and 194 engaged space and made exhibits. This number considerably exceeded all previous records, and was a net gain of 42 over Boston in 1917. The total space, however, was 1200 square feet less than was used in Boston, but no doubt the 1917 figure would have been equaled, if not exceeded, had we had more available space, as many were obliged to use less than they would like to have had.

Ordnance Exhibit.—With the co-operation of the Ordnance Department, who detailed Lieut. A. B. Wallace, Jr., of the Property Division of Ordnance, to take charge of an exhibit of ordnance material, a very creditable and interesting display was made. We were disappointed in not being able to secure some 3-inch and 4.7-inch guns complete, because of the urgent need at that time of these pieces on the fighting front in France. The total cost of this exhibit to the Association was $147.61.

Admission Charge.—At the meeting of the Board of Directors, Feb. 16, 1918, a resolution was passed to the effect that we return to the practice of charging admission to all, irrespective of association membership. We believe that this policy should be continued.

The gross gate receipts, including exhibitors' buttons, were $2,602.75, a gain of $959.75 over 1917. From this, however, must be deducted $245.20, war tax on tickets, making the net gate receipts, including 521 exhibitors' buttons, $2376.55.

The auditor's financial statement, which is presented later, will show receipts and expenditures, but for your information I am pleased to submit a comparative statement for the years 1916, 1917 and 1918. The total space used in 1916 was 37,930 square feet; cost per square foot was 53.5 cents; income per square foot, 53.4 cents plus. Total space in 1917, 43,674 square feet; cost per square foot 62 cents plus; income per square foot, 53.4 cents plus.

Total space in 1918, 42,474 square feet; cost per square foot, 56.8 cents; income per square foot, 58¼ cents; 1918, I believe, was the first time in the history of these exhibits where space earned a profit. This amounted to $912.27. The average total space for three years was 41,357 square feet; average cost per square foot, 57.7 cents; average income per square foot, 55 cents plus.

From the above it will be seen that all surplus, with the exception of the small earnings on space last year, has come from exhibitors' permit fees, gate receipts, contributions, and bank interest.

To carry further the comparative figures, the net earnings for 1916 were $6829.60; 1917, $6701.37; 1918, $8376.12; the average earnings for three years being $7302.36. Out of these earnings we have paid during the past three years, $2000 to the Technical Department of the American Foundrymen's Association, $416.50 to the Metals Division of the American Institute of Mining Engineers, formerly the American Institute of Metals, rebated to 1916 exhibitors, $2018.60, and paid into the War Service Committee Fund, $4529.57, making a total of $9964.67.

We have also prepared a statement of receipts and expenses covering three years, which are appended:

Income

	1916	1917	1918	Average
Space Rental	20228.70	23450.00	24765.00	22814.57
Exhibitors' Permits	3825.00	3900.00	4950.00	4225.00
Gate Receipts	2030.25	1643.00	2376.55	2016.60
Bank Interest	43.98	138.60	137.30	106.63
Contributions	1000.00	5000.00	......	2000.00
	27127.93	34131.60	32228.85	31162.80

Expenses

	1916	1917	1918	Average
Administration	5793.30	6367.40	7732.40	6631.03
Bldg. Rent and Power—net	3421.15	3455.13	3978.02	3618.10
Booths, Decorations, Signs	2426.62	3515.27	3289.98	3077.29
Watchmen and Janitors	306.54	544.69	722.94	524.39
Registration	200.45	267.60	556.88	341.64
Badges	434.26	333.50	612.52	460.09
Advertising and Printing	3684.72	4422.38	3311.37	3806.16
Postage	485.00	298.68	500.00	427.89
Gen. Exp. Labor and Material	321.54	192.41	563.38	359.11
Insurance	32.65	40.55	33.50	35.57
Secretary-Treasurer's Asst.	60.00	245.00	600.00	302.00
Telephone and Telegraph	162.70	81.28	151.54	131.84
Committee Traveling Exp.	1248.68	1340.89	740.38	1109.98
Manager's and Assts.' Travel	720.72	1010.45	910.03	880.40
Exchange	......	......	2.18	.73
Special Expense	......	313.00	147.61	153.54
	19298.33	22428.23	23852.73	21859.76

Reserve for Contingencies.—While we have been fortunate in showing an average earning of something over $7000 for the past three years, I desire to call your attention to the importance of

having a contingency or emergency fund to protect association members against any unexpected loss.

We have had, during this brief period of three years, two very close calls. The threatened railroad strike in 1916 was scheduled to come off just one week ahead of our opening day at Cleveland. Last year at Milwaukee the influenza epidemic closed everything in that city except the Auditorium, on Thursday of the week we were there, and on Saturday night following the day that we closed, the Auditorium was converted into an influenza hospital.

Our contracts protect us against certain emergencies. However, should we be unable to deliver the space, we would be in a very serious situation if we did not have a sufficient reserve fund to tide us over such an emergency. Unlike most going concerns, we demand payment in advance of delivery of goods, and a considerable part of this money is spent in promoting the show previous to the delivery of the goods.

I would suggest that this committee recommend to the Board of Directors, that a certain sum, to be decided upon later, be set aside out of our surplus, as a reserve for contingencies, and that we annually add to this fund as we are able, until it has reached an amount equal to our average yearly expenses.

Opening Exhibits Evenings.—Our rules and regulations usually state that the exhibits may be open one or more evenings at the discretion of the committee on exhibits, but the hours usually announced are for day exhibits only. On several occasions there have been very pressing demands on the part of the local people and some exhibitors, that the exhibits be kept open evenings, and at Milwaukee we were waited on by a committee who were so insistent that it was finally decided to hold the exhibit open on Tuesday evening, on condition that newspaper publicity was not given, and that they would assume the responsibility of notifying the trade. We were all doubtful about results, but believe it was more successful than any of the committee expected it would be. To avoid change in program which results in misunderstanding and complaints, I would recommend for your consideration, that we adopt the policy of being open one night each year, and have it generally understood. Tuesday evening would probably be the most acceptable one of the week.

The books of the Department of Exhibits were audited as of date of Dec. 15, by A. E. White & Co., Public Accountants, and the details are presented in the report of the Secretary-Treasurer for 1918-19.

Respectfully submitted,

C. E. Hoyt, *Manager, Department of Exhibits.*

Annual Report of the Secretary-Treasurer

To the President and Members of the American Foundrymen's Association, Inc.:

We submit herewith the secretary-treasurer's annual report for the year ending June 30, 1919. The conditions affecting membership for the previous year, due to the war, continued through a large part of the past year, and numerous changes in the personnel of the membership have resulted. In nearly all cases, however, the firm membership has been continued and a net gain in membership is shown.

Complete data covering the membership of our organization follows:

Active members, good standing	927	
Active members, delinquent	37	
Active members carried on books		964
Associate members, good standing	110	
Associate members, delinquent	12	
Associate members carried on books		122
Honorary members		17
Total book membership		1103

Total membership paid to June 30, 1919	1054
Resignations of active members during year	7
Deaths of honorary members	1
Deaths of active members	6
Active members dropped for nonpayment of dues	20
Resignations of associate members during year	2
Deaths of associate members	3
Associate members dropped for nonpayment of dues	7

New members received during the year 1918-19, 131, of which 122 were active, and 9 associate.

Accompanying this report is a chart showing the membership of the American Foundrymen's Association, Inc., each year since the date of its organization in 1896.

Change of Office

Although the secretary-treasurer was elected at the annual meeting in Milwaukee, Oct. 9, 1918, he did not assume

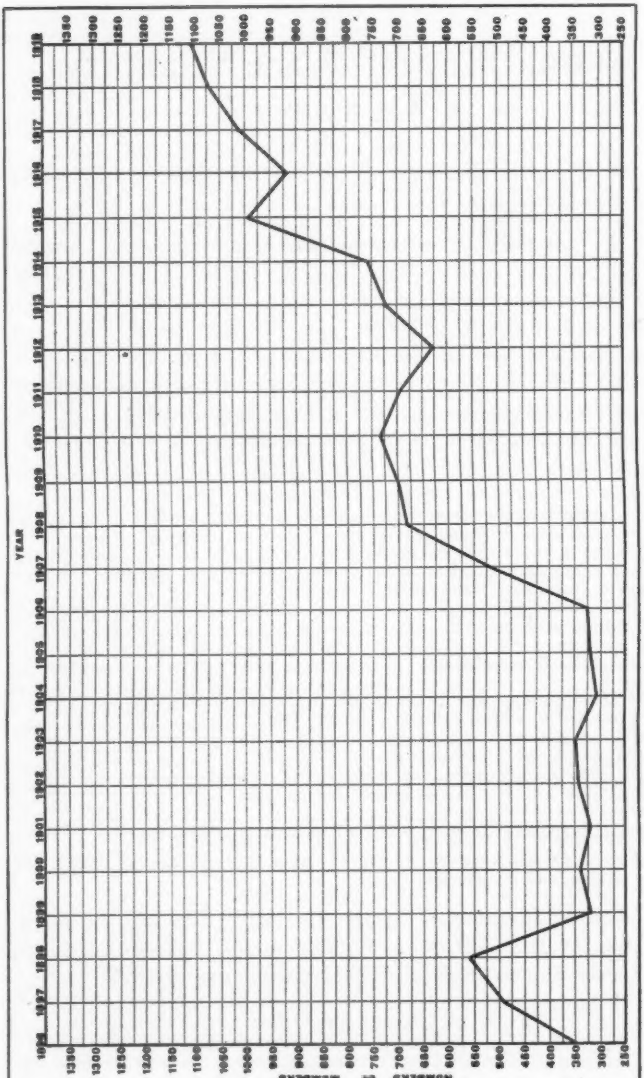

CHART SHOWING GROWTH IN MEMBERSHIP OF AMERICAN FOUNDRYMEN'S ASSOCIATION

the active duties of the office until the meeting of the board of directors in Philadelphia, Feb. 7, 1919.

Following this meeting, the office of the association was moved from Cleveland to 111 W. Monroe street, Chicago. Former Secretary A. O. Backert acted as secretary in the interim during which time the papers and discussions presented at the Milwaukee convention were edited and the bound volume of transactions published.

Finances

The expense of moving the office from Cleveland to Chicago, the necessary furniture and equipment, office rent and additional clerical help added considerably to the expense for the year. Receipts exceeded expenditures by $36.05, compared with $93.80 for the year ending June 30, 1918. The total receipts from all sources amounted to $16,227.19. The total disbursements $16,187.92. Total receipts from dues and subscriptions amounted to $11,406.79. The sum of $1,000.00 was transferred to the technical department from the earnings of the department of exhibits for the year 1918. The sum of $250.00 was paid to the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers from the earnings of the department of exhibits. The largest item of expense was for printing and stationery which amounted to $5349.76, an increase over the previous year of $715.96. The amount derived from the cost keeping account for the year was $816.12, and although the association was put to the expense of furnishing each subscriber to the cost system with a revised copy of the system, a profit to the Association from the cost account resulted.

Research Fund

The association's research fund created in 1916 by a contribution from the Cleveland local convention committee now amounts, with interest, to $372.13. It is earnestly hoped a substantial addition will be made to this fund, making it sufficient to enable the association, through some

of its committee activities to carry on a work for which this fund was intended.

Appended hereto are the financial statements of Ernst & Ernst, certified accountants, who audited the books for the technical department, and of White & Co. who audited the books for the department of exhibits.

For the aid and support given him through the year by President A. O. Backert, the board of directors, and his assistants, your secretary-treasurer extends his warm appreciation and sincere thanks.

Respectfully submitted,

C. E. HOYT, *Secretary-Treasurer.*

AUDITOR'S FINANCIAL REPORT OF TECHNICAL DEPARTMENT

Chicago, Aug. 12, 1919.

Mr. A. O. Backert, President,
The American Foundrymen's Association, Inc.,
Cleveland, Ohio.

Dear Sir:

As requested we have audited the cash receipts and disbursements of the American Foundrymen's Association, Inc., Chicago, for the year ended June 30, 1919, and submit herewith our report.

Following is a condensed statement of the cash transactions for the period under review:

CASH BALANCE, June 30, 1918—	
As shown by our previous report	$ 688.65
Transactions for the Year	
RECEIPTS—	
As per attached schedule	16,223.97
	16,912.62
DISBURSEMENTS—	
As per attached schedule	16,187.92
CASH BALANCE June 30, 1919	$ 724.70

We compared all checks returned by the bank with the original cash book entries and traced all recorded receipts to the bank statements and reconciled the balance shown on the book with the figures contained in signed statements received directly from the depositaries.

We submit herewith a reconciliation of the bank balance and direct attention to an item of $10.00 representing a deposit shown by the April bank statement which amount is not reflected in the books. Due to the fact that the receipts consisted of a large number of $10.00 items and

the absence of duplicate deposit tickets we were unable to locate the $10.00 item in question.

We traced all cash received in payment of dues, etc., directly to the credit of the members' accounts and with the exception of the following, no errors were noted.

On July 8, 1918, an item of $10.00 under name of Niles Anderson, appeared on the books and had been deposited, but we were unable to locate the individual card to which this amount should have been posted.

We noticed the following amounts had been credited on the individual cards, but not entered in the cash receipts book: July 17, 1918, W. A. Coventry $10.00; September 5, 1918, W. W. Wallace $10.00; October 7, 1918, H. G. Walton $10.00.

We noted that during the year under review, duplicate payments of dues in the amount of $30.00 had been received by the association, but we were advised that this amount would be refunded to the members having made the payments, at a date subsequent to June 30, 1919.

From a letter on file we learned that a check was given in payment of the H. G. Walton account at the convention, Oct. 7, 1918, and cleared through the Central National Bank, Cleveland, Ohio, October 24, 1918.

We verified the footings of all receipts and disbursements for the period under examination. All disbursements were supported by original invoices and properly signed vouchers. A schedule is attached showing the amount of membership dues unpaid at June 30, 1919. We verified these amounts by trial balance, but did not correspond with the members to further verify the records.

We present below a trial balance of the General Ledger after the close of books at June 30, 1919:

Harris Trust & Savings Bank..........	$ 352.57	
Superior Trust & Savings Bank..........	372.13	
Emblem Account	40.50	
Furniture and Fixtures	415.50	
Printing and Stationery	401.87	
Surplus		$1,582.57
	$1,582.57	$1,582.57

Very truly yours,

(Signed) Ernst & Ernst,

(SEAL) Certified Public Accountants.

Cash Receipts and Disbursements

The American Foundrymen's Association, Inc., Chicago

One year ended June 30, 1919.

CASH BALANCE June 30, 1918, as shown by our previous report		$688.65

TRANSACTIONS FOR THE YEAR

Receipts

Dues and Subscriptions	$11,406.79
A. F. A. Share 1918 Exhibition	1,000.00
Sale of Furniture and Fixtures	42.50
Cost Work Account	816.12
Exhibition Committee Account	633.30
Convention	2,304.50
Interest	20.54
Discount	.22
Total Receipts	$16,223.97

Disbursements

Printing and Stationery	$ 5,349.76
Extra Help	130.00
Rent	150.00
Auditing	115.00
Packing Material for Shipment	76.30
Special Printing	49.10
Office Expense	264.01
Traveling Expense	425.35
Convention Expense	3,236.25
Administrative Salary	2,175.00
Office Salaries	1,517.35
Postage	762.25
Committee Meeting Expense	1,651.71
Refunds of Dues	10.00
Dues in other Associations	15 00
Addressograph and Cabinet	208.00
Cost Work Committee	44.04
Exchange	8.21
Discount	.59
Total Disbursements	$16,187.92

RECEIPTS EXCEED DISBURSEMENTS	36.05
CASH ON DEPOSIT JUNE 30, 1919	$724.70

Auditor's Report of the Exhibition Department

Chicago, Jan. 23, 1919.

President and Directors,
American Foundrymen's Association, Incorporated,
Cleveland, Ohio.

Gentlemen:—

We have examined the books of the Department of Exhibits of the American Foundrymen's Association, Incorporated, for the period from Dec. 24, 1917, to Dec. 15, 1918, and submit herewith the following reports which we have prepared:

Balance Sheet at Dec. 15, 1918.

Profit and Loss Statement for the period from Dec. 24, 1917 to Dec. 15, 1918.

Agreement of Surplus—Income Account.

We also include a separate schedule of the detail of accounts receivable.

Our examination of the above records included a check up of all sources of income including space rentals, permits, gate receipts, etc.

All cash records including manager's petty cash account with the Second Ward Savings Bank, Milwaukee, and the general fund account with the Superior Savings & Trust Co., Cleveland, Ohio, were found to agree with statements submitted from these institutions for the period covered.

Included in the item of Booth Expense on the Profit and Loss Statement is material for booths amounting to $500.00 and skids and jacks $50.00 which are on hand and can be used at future exhibits.

We would suggest that the manager's Petty Cash Fund be made sufficiently large to avoid using gate and other receipts to meet daily expenses at the exhibitions. Two bank accounts should be used, one for Gate Receipts and one for manager's Petty Cash.

It would of course, be possible to transfer (by check) amounts from the Gates Receipts Account to the Manager's Petty Cash Fund if the need arose. In this way the identity of the two funds would be kept distinct, a very desirable thing in our opinion.

There should also be a clear division between Profit and Loss and Surplus. Surplus is the combined earnings of previous years. Profit and loss is the profit or loss of the present year. Donations from previous earnings and any other charges against previous years should be charged against surplus.

The Profit & Loss account for the current year should not be opened until the time when the books are closed. Any charges or income during the year should be charged or credited to specific expense or income accounts, not to Profit & Loss.

In view of the possibility of serious loss due to postponement or cancellation of any exhibit, it would seem desirable to create from the Surplus Account a special fund that might be called a Reserve for Contingencies. This fund should be kept intact and used only in case of unexpected loss. By investing this fund in high grade securities its permanent nature would be better assured, to say nothing of the greater interest yield.

Your very truly,
A. E. White & Co.

American Foundrymen's Association, Incorporated

Balance Sheet—Department of Exhibits

Dec. 15, 1918.

ASSETS—	
Cash in Bank	$12,471.56
Accounts Receivable	33.00
Furniture and Fixtures	223.50
	$12,728.06
LIABILITIES—	
Surplus—Income	$12,728.06

Department of Exhibits

American Foundrymen's Association, Incorporated

Profit and Loss Statement

Year 1918 (Ending Dec. 15, 1918)

INCOME—

REVENUE FROM EXHIBITION AT MILWAUKEE

Gate Receipts	$ 2,376.55		
Space Rent	24,950.00		
Exhibitor's Permits	5,000.00	32,326.55	
Interest on Deposits in Bank		137.30	
Total Revenue			32,463.85

EXPENSES—

Advertising	3,047.90	
Power	2,277.51	
Booth Work	2,939.78	
Signs	350.20	
Registration	556.88	
Watchman and Doorman	248.50	
Insurance	33.50	
Badges	612.52	
Building Rental	1,500.00	
Janitor Service	474.44	
Cleaning and Repairing	200.51	
Installation, Labor and Material	337.85	
Ordnance Exhibit Expense	147.61	
Space Rent	185.00	
Exhibitors' Permits	50.00	
Manager's Salary	5,900.00	
Printing and Stationery	563.47	
Postage (Exclusive of Advertising Postage)	200.00	
Committee's Traveling Expenses	740.38	
Salary, Secretary-Treasurer's Assistant	600.00	
General Expenses	225.53	
Telephone and Telegraph	151.54	
Manager's and Assistant's Expenses	910.03	
Stenographers' and Assistants' Salaries	1,755.45	
Office Supplies	76.95	
Exchange	2.18	24,087.73
1918 Operating Profit		$ 8,376.12

Address of Welcome

By Thomas Devlin, Philadelphia

In the name of and on behalf of the Philadelphia Foundrymen's association, I tender to your association a most sincere, cordial and brotherly welcome to Philadelphia, the city of homes and brotherly love, and the city from which your youthful start was made 28 years ago. I am delighted to be the spokesman in extending the greeting to you, but regret that I have not the ability to greet you in a satisfactory manner.

I tried to guess why I was selected, especially as the membership contains many able men,—men who are competent to greet and welcome you in language that would have charmed you. Then, why was I unanimously selected? Perhaps it was in consequence of my being over 65 years in the foundry business or perhaps it was to show the young men that 65 years of hard work do not necessarily shorten one's life. If the latter was the object, I wish to confirm that thought by stating that I am still on the job from 8:30 a. m. until about 3 or 4 p. m. and eat but two meals a day.

Early Salary Was $1.50 Per Week

Still another thought; could it be possible that the unanimous voters hoped that I would explain the conditions existing in those days of long ago and do it in the form of a word picture, somewhat the equivalent of a moving picture show, depicting the privations, hardships, labors, the ups and downs, and disappointments that came into my life from that fourth of August, 1854, when I entered the office of Thomas R. Wood & Co., Ninth and Jefferson streets, Philadelphia, at the munificent salary of $1.50 per week, which was paid me every Monday for the previous week's labor? Monday was selected by the company so that I might not waste my salary foolishly on Saturday or Sunday.

I had much to contend with, but had good health, a cheerful and hopeful disposition, and was not afraid of work. I took pride in doing well what was given me to do. Progress

was slow, but I kept on. Perplexing difficulties were in evidence all along the line as they are today, but of a different character. Debits there were and these were duly recorded.

But then, as now, there was also a credit side. Good, honest, faithful service will be rewarded. Payments sometimes are slow, and we may think them long overdue; but, young men, do not be discouraged; do your best. Circumstances and conditions often change when least expected and the priceless friendships that you make are a very great source of pleasure and satisfaction, and for me are equal to cash reserve in bank. Young men, from my observation and experience, the chances are better today than they ever have been during my 65 years' experience, because there are so few who are willing to serve the necessary probation or apprenticeship and give the best that is in them in order to reach the goal for which they strive.

Organize Philadelphia Foundrymen's Association

I had intended to confine my desultory remarks largely to the history of the foundry association, but you all know an Irishman is privileged to say what he wants to say and explain his meaning afterwards. The Philadelphia Foundrymen's association was organized about 1888 with Henry T. Asbury as president and Stanley G. Flagg Jr., as secretary. There seems to have been a break in the meetings, but the organization was given a fresh start in January, 1891, when it was entrusted to new men. Howard Evans, a man who doesn't know such a word as failure, was elected secretary; Francis Schumann, a bright and big man in every sense of the word, was elected president; and Josiah Thompson was elected treasurer. If the North Penn bank had had him for treasurer, the poor widows and orphans would not now be mourning the loss of their all.

The Philadelphia Foundrymen's association had men who did things. They had no time for slackers. Among the membership were such men as Abram C. Mott, W. H. Pfahler and Thomas I. Rankin, of the Abram Cox Stove Co.; Antonio C. Pessano, of George V. Cresson & Co.; Thomas Glover, of

Morris & Tasker Co.; Stanley G. Flagg Jr., of Stanley G. Flagg & Co.; P. D. Wanner, of Millert Foundry & Machine Co.; Walter Wood, of Camden Iron Works; James S. Stirling, of Harlan & Hollingsworth Co.; A. E. Outerbridge Jr., of William Sellers & Co.; A. A. Miller, of *The Iron Age;* and others.

I have no doubt some of the names I have mentioned are well known to many of your membership; consequently you will not wonder that they were successful as business men anxious for new worlds to conquer. One of the questions taken up by them was that of calling the foundrymen of the United States and Canada to meet here. That question was discussed many times and finally decided upon. Howard Evans, the secretary, undertook the task of finding the names and addresses and sent out invitations dated June 28, 1891. There were responses and representatives assembled here in July, 1891, from every state with one or two exceptions. The first meeting was held in the Manufacturers' club, July 21, 1891. The convention was a complete success for on or about July 29, 1891, the American Foundrymen's association was delivered by that convention to Mr. Schumann and Mr. Evans, who in turn transferred it in swaddling clothes on that hot summer's day 28 years ago to the tender care of John A. Penton.

This is a brief narrative of the triumvirate which had most to do in conquering a world of difficulties and securing a very important and exalted place in the business world for the foundry trade. I believe Evans, Schumann and Penton should be honored as immortals for what they did through the instrumentality of their foundling in bettering conditions and promoting scientific management of the foundry.

Association Renders Great Service to Industry

If I closed without properly acknowledging the great service your association has rendered to the foundry interests of this country, I would have failed in an important duty. Consequently I bestow well earned praise and congratulations on the successive managements which followed Mr. Penton and thus relieved him of his charge because he was too busy a man to give it the care it needed.

Fortunately there was no mistake made by the transfer and I am compelled to admit that the Philadelphia Foundrymen's association has no monopoly of the great men in the foundry business. The American Foundrymen's association in securing the services of Dr. Moldenke was very fortunate in more ways than one. His fine personality, sweet and pleasant manners attracted able and efficient aids to bring the youngster through the mumps and teething season and when its faculties were developed, so as to be in a receptive mood, he furnished it regularly with pure and unadulterated scientific knowledge drawn from the fountain head, where he kept it stored up for instant distribution.

That is the record up to Mr. Backert's time. Nothing remains to be done but to keep steadily on with the work thus set in motion. I am not familiar with the men who as directors gave efficient aid in accomplishing results nor the membership which supported you, besides I don't want to enlarge too much for fear of having our members desert us in a body and join your association, leaving me president of an organization that *did* exist.

The great and unparalleled success of your association and its achievements are proof that no matter how it was started, the men who have had the direction of its affairs have accomplished remarkable results. They have done good work and have elevated their trust far beyond anything that the sponsors considered as possible of being accomplished. We of Philadelphia feel justly proud of our offspring and congratulate you for your very intelligent management and for the grand success you have achieved.

In conclusion I greet and welcome you to Philadelphia. I welcome you as an American citizen, as a citizen of Pennsylvania and as an adopted citizen of Philadelphia, the dearest spot on earth to me. I extend a *Cead Mille Failthe*—"One hundred thousand welcomes!"—to the American Foundrymen's association and hope that your stay may be pleasant and that you will come again and that I will get the unanimous vote to welcome you, providing your return is not delayed more than 10 or 15 years from 1919.

The Crisis

By Hon. James M. Beck

I want to speak to you tonight very earnestly and very simply about that which I have called "The Crisis." To my mind the world was never in quite as grave danger as it is today, and it is a danger that does not come from without, but from within. There is a chapter of American history of which most of us are very ignorant. We know the epoch from Bunker Hill to Yorktown, it is schoolboy's talk in America, and we naturally take pride in the embattled farmers' brave struggle against tremendous odds, but that which followed Yorktown is very much like the old-fashioned Victorian novel which always concluded with the marriage of the happy pair and never said anything about what took place after marriage.

What Came After

After Yorktown came seven or eight years of tremendous stress out of which grew that most wonderful piece of machinery in all the world—the constitution of the United States. Bolshevism and anarchy swept this government after Yorktown until even the brave heart of George Washington—a heart that never failed him in strength even in the darkest days of Valley Forge—fell into the deepest depression by the extraordinary happenings that were going on in the newly emancipated colonies. There was a perfect wave of lawlessness. Class was arrayed against class, colony against colony, interest against interest. It was, as at this time, the end of a world war. As Washington said, the whole world was in an uproar. As he said again, "The problem is to steer between Syclla and Charybdis." The situation became so acute that finally civil war broke out, chiefly in Massachusetts, with what was called Shay's rebellion, when, as we would say today, Bolshevists seized the executive departments of the government, took the

court houses, drove out the constituted authorities, confiscated debts, seized the little factories, if factories there were and in that way attempted to bring about the very state of affairs that exist now in Russia. I want to read to you, as illustrating the intense anxiety of even so brave a man as Washington, two things that he said at that time.

Washington's Alarm

"I often think of our situation," he wrote, "and view it with concern. From the high ground we stood upon, from the plain pathway which invited our footsteps, to be so fallen, so lost, is mortifying; but everything of virtue has, in a degree, taken its departure from our land."

And when he heard of Shay's rebellion in Massachusetts, which required an army of 5000 men, then a relatively large force, to put down, this cry of anguish came from the Father of his country in far-off Mt. Vernon:

"What, Gracious God, is man, that there should be such inconsistency and perfidiousness in his conduct? It was but the other day that we were shedding our blood to obtain the constitutions under which we now live, and now we are unsheathing our swords to overturn them. The thing is so unaccountable that I hardly know how to realize it or to persuade myself that I am not under the illusion of a dream."

The confusion became so great that barbers plastered their walls with the worthless currency of the nation. Our government bonds were worth about 25 cents on the dollar. Foreign nations refused to recognize the new republic, and finally in that hour of acute despair, all turned to Washington. Washington, leaving again the sweet retirement of Mt. Vernon, came to the historic city of Philadelphia and rallied a few faithful spirits about him. The constitutional convention began its deliberations. But out of seventy-three men appointed to the constitutional convention, only fifty-five ever took the pains to attend, and of those fifty-five, only thirty-nine remained until the last session, and of those thirty-nine, sixteen refused to sign the document that was to confer immortality upon them all. In

referring to the task which confronted the few faithful delegates, Washington said:

"It may be that no plan that we can propose will be adopted. Perhaps another dreadful contest is before us. If, to please the people, we do that which we cannot approve, how can we afterwards commend our work to them? Let us raise a standard to which the wise and just can repair; the event is in the hand of God."

And for four months, with that inspiration of appealing to the best in men, they met in Independence Hall and at the end of four months, after a bitter struggle, the great document that we call the constitution of the United States was completed. As the Fathers commenced to sign it, the great sage of Philadelphia, Benjamin Franklin, pointing to the sun—the half disc of a sun that was represented upon the chair in which George Washington sat, said, "I have often wondered during the progress of this convention, whether that sun is to be a rising or a setting sun. Now I know it is a rising sun."

New Forces on the Horizon

And through the past century it has proved a rising sun. And yet our institutions, raised under this constitution, are in more deadly peril than they have been within the memory of living man, and that for the very obvious reason that through the very power of multiplied association due to machinery, there have grown nongovernmental forces so stupendous as to threaten the integrity of government itself. It has come like a black shadow in twenty-five years. Why, twenty-five years ago the Knights of Labor was a great national labor organization. You will remember the first attempt that was ever made to force their will upon the people of this country, not by the ballot, which is their constitutional right as the constitution provides, but to force it upon the people in a manner so malevolent and cruel that Prussia need not be ashamed of anything they have done.

Why do I say that? When a dispute arose in 1894 between the employes of the Pullman company and the Pullman operators, thereupon, under the leadership of labor organizations, for

the first time, a virtually nationwide strike was attempted. Twenty-two railroads leading into Chicago that held control of the necessaries of life were sought to be paralyzed. It was felt that as food is indispensable to man, as women and children would starve if those railroads could be successfully tied up, nothing remained but for the American people to succumb in the presence of potential starvation. I think it is to the glory of that great President, Grover Cleveland, that he said that the mails would be moved and the channels of interstate intercourse would be kept open if it took every Federal bayonet that was then within the control of the Federal government.

Organized Coercion

Well, that passed away, and a far greater organization arose, an organization numbering not 600,000, but 3,000,000, and they attempted to do the same thing, to enforce their will upon the people, not by means of the ballot, as I say, which is their right, but by economic pressure through the method of the boycott. I happened to be counsel in the Danbury hatters' case and so in the Buck Stove & Range Co. case, and I wish I had time to recount the cruel tyranny that was exerted upon the employers of labor in those cases. At all events, the pressure of 3,000,000 men was brought, by the most wonderful organization, to bear upon two men, or at least two groups of men, in order to crush them unless they would dictate to their employes, who desired not to be unionized, the necessity of taking out union cards and becoming members of the labor union.

But the boycott passed as too mild a method. But as long as this method was merely one of compelling the employer to do that which otherwise he might not do, while it nullified every provision of the Declaration of Independence, and the great principle of individualism which the constitution of the United States was intended to make firm and stable, yet nevertheless, in a day of great organization those who defend this form of duress can at least say it is an open fight between powerful groups of employers and powerful groups of employes.

Therefore, we pass to the last, the final and most terrible stage of this wretched business, namely that which in England they call "direct action;" namely, the power of labor organizations to say to the government, "We will not depend upon the ballot, we will not depend upon the methods of constitutional government, but we will starve the women and children unless you will agree to do that which we demand." This of course means the destruction of civil government and the substitution therefore of that most hateful of all rules, the rule of a class. I do not care what class it is, whether it is the class of the employer or the class of the employe, the rule of either as a substitute for civil government would be indefensible tyranny.

It is remarkable how far this pernicious doctrine has gone already. Only last June, in a vote taken in the great National Trades' Congress of England, the representatives of the working men of England in the mines and railroads and transport services determined they would have direct action to impose their will upon the Mother of Democracies. They would do so for what purpose? For a purpose which would commend itself to any fair-minded man? No; to nationalize coal mines. How? By paying to the operators or owners the fair return for their property? Not a bit of it; the demand upon the British government at this hour is that the government by force shall confiscate every privately owned mine in England and not give the owners one penny in lieu either of capital or royalties, except that which the labor leaders in England have called compassionate grants to a few of the operators who, by reason of poverty or other circumstances, would be given a dole.

New Demands

Moreover, last June, the labor congress of Great Britain in the same vote of two to one for direct action, said to their government, "we *demand* that you take every soldier out of Russia," thus attempting to substitute their will for the foreign policy of Great Britain as determined by its parliament according to the British constitution. Within a month they met again, and again they said to the British parliament by an overwhelming vote, approaching unanimity, "You will national-

ize the coal mines by confiscating the owners' property, or we will reconvene," for the purpose, as was plainly intimated, of applying this direct action, which is nothing more than civil war. The threat today is to starve this victorious people into submission to the rule of a soviet class. And if this class were to triumph in its unholy purpose, in this bloodless but none the less cruel civil war, we would witness the most pathetic spectacle imaginable—the Mother of Democracies, a nation that has borne upon its broad shoulders the destinies of a liberal civilization for nearly a thousand years, led in the chains of a soviet government. Now this is not going to happen, please understand that, but this great people are so near the abyss that we, here in the United States, have very considerable ground for pause.

Are We Too Optimistic?

We are so optimistic and good natured a people that we think all is right. We seem to believe these violations of all the proprieties of civil life can happen and that nothing will follow. The result is that the situation, instead of growing better, grows worse from year to year, and today who can tell what is going to happen?

Is there any real controversy between the steel employes and the steel companies as to their conditions of employment? That practically does not figure in it, because only one-fifth of them are really organized. The steel strike is the result of outside pressure by a great body which feels that the Steel corporation is a stone wall of defense of the whole industrial liberties of America. This strike is the attempt to destroy that stone wall in order that labor organizations can be so widespread that in the twinkling of an eye they can choke America into submission, and destroy liberty, freedom and the inalienable right of the individual to sell his labor as he pleases, together with the inalienable right of any man to engage in business in any way he pleases or not to engage in it at all. Have you read what the gentleman who is running the steel strike for the labor organization said in 1915—I shall not go back to 1912, but in 1915 he declared he believed in the destruc-

tion of all government, and in the accomplishment of that destruction in the only way it could be accomplished—by starvation; by pressure; by treating free industrial America as the Prussians treated Belgium; by making the little children in the streets feel the terrific character of the pressure upon them.

Only a Skirmish

We, of course, hope and believe that this particular fight for freedom from the oppression of labor domination will be won. But suppose it is won. It is but a skirmish in a vast struggle—a struggle for your constitution; a struggle to preserve the form of government that was adopted by our fathers; a struggle to preserve the form of government under which this country has existed for a hundred and thirty-two years, and under which it has immeasurably prospered until today it is potentially the greatest nation in the world.

If the constitution of the United States were to perish tomorrow, our fathers could say with pride as a great English historian, Freeman, said in 1862, that even then it had diffused more happiness, contentment, peace and prosperity over a wider range of country than any similar form of government had ever done in the whole history of the world. It is that constitution, proclaimed by Gladstone the most perfect piece of work ever struck off by the brain and purpose of man at a given time, that constitution which, when a greater than Gladstone, William Pitt, first read it, he said, "It will be the admiration of all ages and the pattern for all future governments"—this constitution, the admiration of the world, under which we have grown great, is threatened by a spirit which says, "The legislative power is not in your congress, the executive power is not in your President, the judicial power is not in your courts, but on the contrary in a labor organization." If it can acquire sufficient strength, by the mere pressure of direct action, it can say to the President, it can say to congress, it can say even to the judges, "You will do what we say or we will inflict upon this country such widespread suffering that to men the loss of their constitution would be more tolerable than the starvation of their women and children."

Do you remember what took place only in 1916? How the same arrogant would-be tyrants, with stop watches in their hands, said to the American congress and to the American President, "You will pass a law within a given time and if you fail to do it, every railroad in the United States will stop." And we yielded. Congress passed the Adamson law, the courts sustained it, wages were raised by statute, and of course there was another triumph to be scored for this insidious conspiracy against free government.

I think in conclusion that the best thing that we can do is to reiterate those words of Washington and invoke them as the spirit with which we should meet this grave peril, "It is only too probable that no plan which we propose will be adopted; perhaps another dreadful contest is to be sustained; if we adopt that which we cannot approve, how can we afterwards approve our work to the people? Let us raise a standard to which the wise and just can repair; the event is in the hand of God."

It is time for Republicans and Democrats, it is time for all patriotic Americans, to unite and take this nettle of Bolshevism and crush it. It is time for all of us, for the time being, to forget our troubles in other parts of the world. The most immediate necessity that we have and the greatest service that we can render, even to our faithful allies, is to solve this seemingly insoluble problem in our midst. The problem is to restore the reign of law; it is to enforce the laws we now have upon the statute books. But for my part, in addition to the laws we now have which forbid these indefensible restraints of trade, I would add another, namely—that if any combination, either of employers or employes, shall attempt to subvert government by saying to the President or the congress of the United States, "You will do so and so or we will starve the American people by refusing to mine coal or by paralyzing their railroad supplies," that that offense shall be the equivalent of sedition and punished accordingly.

Report of A. F. A. Committee on Safety, Sanitation and Fire Prevention

The Committee on Safety, Sanitation and Fire Prevention of the American Foundrymen's association recognizes at this time that a new factor, namely the United States Bureau of Standards, is now engaged in compiling new safety codes for various industries, including a standard code for foundries.

Your committee requests the American Foundrymen's association that it be authorized, during the coming year, to keep in touch with the United States Bureau of Standards and to co-operate with the bureau in the compiling of the proposed new foundry code.

Your committee wishes also to bring to the attention of the American Foundrymen's association the fact that various states such as Wisconsin, New Jersey, New York, Ohio and California are all compiling industrial lighting codes or have practically completed such codes. These codes will effect the foundry industry in the states referred to.

It is recommended, therefore, that the American Foundrymen's association through this committee watch the developments of these various state codes.

It is recommended, also that the scope of your committee be enlarged with a view of giving special study to the welfare of employes in foundries and to improving the splendid spirit which has always existed between the employes and the management among the foundries that are members of the American Foundrymen's association.

Accidents cannot be entirely eliminated by mechanical means, foundry regulations, or federal regulations. About 75 per cent of foundry accidents can be eliminated, however, by educational work among employes and by efforts made to safeguard and improve the relations between the management and the men. It is recommended that the American Foundrymen's association send out a questionnaire to all foundries

on its membership, requesting information as to what they are doing along lines of accident prevention and welfare.

In view of the importance, therefore, of all these problems your committee recommends that a Committee on Safety and Accident Prevention be reappointed. It is important that the members who are appointed on this committee should be able to give time and be able to attend to one or two meetings that are held annually.

F. H. Elam,
Richard Moldenke,
Paul B. Morgan,
C. E. Pettibone,
Franklin H. Wentworth,
R. H. West,
Victor T. Noonan, *Chairman*.

Tentative Fire Prevention Regulations

1.—All foundry, pattern and storage buildings shall be of fire resistive construction.
All pattern shops, storage buildings, warehouses, and offices shall be equipped with sprinkler systems.

2.—All pattern storage buildings shall be subdivided by fire walls.

3.—All sections of foundries devoted to the cupola, air furnace, converter, crucible, open-hearth or electric furnaces, shall be entirely of fire-resistive construction.

4.—Foundry cupboards should all be of metal construction.

5.—It is recommended that metal flasks shall be used in place of the present wooden flasks, as required, this being a step toward the conservation of wood and also a prevention against fires, within the foundries.

6.—All oil stores shall be kept within metal containers in fire-resistive oil houses.

7.—All foundries shall have organized fire brigades.
Hold brigade fire drills at irregular intervals, at least once a month.
Have written reports of all brigade drills and fires.

8.—Fire hose shall be used for fire protection purposes only.
Keep all fire appliances clean and accessible, and see that they are constantly ready for use.

9.—Provide brigades with modern means for fighting fires.

10.—Have regular inspections made for fire hazards.

11.—See that electric wiring is kept in repair and not abused.

12.—Guard against spontaneous combustion in stock, as fires may start from this source. Spontaneous combustion is a hazard from which

fires may start in the fuel and oil supplies, especially in the oils used in mixing the cores. Linseed oil is very dangerous as regards spontaneous combustion if it comes in contact with rags, sacking, waste, or other substances. Spontaneous combustion is also a hazard where accumulation of oil and waste and oily overalls occur in tool cupboards and lockers.

Recommendations

1.—Install the following appliances:
  a.—Metal waste containers.
  b.—Safety cans for inflammable liquids.
  c.—Metal ash cans.
  d.—Fire-resistive lockers for employes.
  e.—Wire guards on all gas and electric lights.
2.—Forbid the use of "strike-anywhere" matches.
3.—See that electric wiring is kept in repair and not abused.
4.—Get co-operation of employes in the care and use of all fire protection appliances. Employes should be encouraged to report any condition that may cause fire.

What You Need to Fight Fire in Your Foundry

1.—Fire extinguishers.
2.—Water pails, casks, and bucket tanks.
3.—Chemical engines.
4.—Axes and hooks.
5.—Stand pipes and hose.
6.—Sprinkler system.
7.—Fire alarm.

Common Hazards That Imperil Many Plants

1.—Boilers, radiators and furnaces.
2.—Electric light, heat and power.
3.—Gas light, heat and power.
4.—Oil lamps.
5.—Candles.
6.—Torches.
7.—Dirty chimneys and flues.
8.—Lighting and spontaneous combustion.

To Insure Fire Appliances Being Ready When Needed

1.—Be sure to see all water and standpipes are protected from freezing.
2.—See that chemical extinguishers, pails, casks, etc., are clean, accessible, and guarded from danger of freezing.
3.—Have extra charges for extinguishers always on hand.
4.—See that all employes understand use of appliances.
5.—Test fire pump regularly.
6.—Replace defective appliances at once.
7.—See that fire appliances are in their proper places at all times.

Uniform Costs in the Foundry Industry

By C. E. Knoeppel, New York

Perhaps the greatest problem before American industry today is that of determining accurate cost of production. Industry is becoming so complex, our tax laws are so intricate and the matter of accurate returns are so important that the concern operating without knowledge of costs, is in the least possible position to conduct its business to the best advantage. Another and perhaps the most important reason why costs must be accurately ascertained, is that to enable the manufacturer to determine just what he can voluntarily do in the way of increasing wages and arranging for profit-sharing plans, and if necessary, to offset the unreasonable demands on the part of his workers, he must know where he stands with reference to his production costs.

Some years ago a trade paper contained this choice bit of logic:

"The surgeon, for instance, certainly ought to be satisfied with his job. When he wants an extra five hundred, all he needs to do is to single out one of his well-nourished patrons, prod him viciously just below the first floating rib until he grunts and then utter those three magic (likewise remunerative) words—'appendicitis, operation imperative.' This is effective salesmanship. Could any manufacturer land a contract with such dispatch? Hardly. Which is quite different from the manufacturing business. If a manufacturer wants to squeeze out an extra $25, he will have to spend a couple of weeks with his cost cards and figures and sweat and snort and chew his nails way up to the knuckle and finally when he does locate a twenty-five that he might possibly grab if he slips up to it quietly and it does not happen to see him first, along comes an unexpected bill for something or other and gobbles it up."

Factors Which May Cause Failure

If we eliminate such considerations as lack of capital, unwise credits, extravagance and fraud, there are three factors which whether considered separately or in combination, can cause distress to an industrial concern. These are: Lack of

systematic production methods, failure to ascertain accurate costs, and lack of uniformity in costing or in bidding on work.

It is difficult to bring about agreements as to prices. A manufacturer once stated: "We no sooner agree upon a price, than it is a race to the telephone to see who can take orders at prices a little under those fixed."

A careful study of the situation leads to this conclusion. Agreement as to price is not necessary. The comparing of bids is not altogether an essential. Combination to control a local situation is not the solution. There should be such uniformity in ascertaining and compiling costs and making estimates as to insure against wide differences in prices. In brief a measure making possible stable prices without any general agreement or secret understanding is needed.

I believe that I am safe in saying that there are two fundamentals in business, which stand out so prominently as to admit of no argument.

First: Every manufacturer who furnishes a product of good quality and who can make reasonable deliveries is entitled to his share of the available business at a fair and reasonable margin of profit.

Second: Any concern which purchases a product below the cost of production is enjoying something to which it is not entitled and which really belongs to the manufacturers of the particular product.

Why Bids Are High

If, after providing uniformity and accuracy in cost keeping, a concern finds that it is consistently higher in its bidding than others, it can only mean that it is not operating efficiently, or that it is adding too much profit to its costs.

Knowing these things, the company is in a position to check up its weak spots and determine where the faults are and then correct them, which will mean lower costs and better operating conditions. If it can find no opportunity to reduce its cost, and this would be a rare case indeed, it means a reduction in the rate of profit must be made until conditions are better. At any rate uniformity in costs means intelligent competition as well as furnishing a means for increasing operating results. Many manufacturers have told me that they have no objection to the hardest kind of competition when

they know that their competitors are operating intelligently along uniform lines and with full knowledge of the true conditions.

Considering the foregoing as well as the statement made some years ago by the Federal Trade commission, that only 10 per cent of the manufacturers and merchants know the actual cost of manufacturing and distributing goods, and that only 25 per cent of the business corporations of the country made over $5,000 a year, the only conclusion possible is that the greatest problem confronting industry is the matter of arranging for uniformity in keeping accurate costs.

There is no question but what industry in this country is headed for an 8-hour day and perhaps the inability to use piece work and bonus. The time is also coming when the government is going to take some action with reference to the matter of cost keeping.

Bidding Against One's Self

Recently I was told of a case where a concern contracted to furnish castings at $2.85 per hundred pounds. When it became apparent that money was being lost somewhere, an investigation was made with the result that the actual cost of this particular work was found to be between $4 and $5 per hundred pounds. This naturally brings up another point. Not only does the buyer profit to the extent of the difference between the cost to the foundrymen and the price the buyer pays but he will expect some of the other foundrymen when the present contract expires, to furnish him castings for a price not much in excess of $3 per hundred pounds. If he cannot get a quotation near this figure, and he can hardly be blamed under the circumstances for not wanting to pay $5 per hundred pounds, he will advertise his requirements until some foundryman who must have the work at any figure, or who does not know his exact costs, will give him a bid that is satisfactory, and as a result the honest, intelligent foundryman is placed at a decided disadvantage. But was not some foundryman to blame in the first place?

A manufacturer writes you that he is in the market for castings and offers prints and specifications and you carefully analyze the situation and make him a bid on the work. Later you call upon the manufacturer and he tells you that he would like to give you the order very much and quietly informs you that your price is too high and that as long as you cannot give him a better price he will be forced to place his contract elsewhere. You reconsider the quotation carefully and finally make him a better price. Perhaps you get the order and perhaps you don't. It all depends upon the number of bidders in the field. Further, the manufacturer no doubt advanced the same argument to all who bid on the work. It is often done. He fully realizes and is secure in his belief, that each one is in ignorance of the prices quoted by the others and as a general rule he is in a position to say that he has an even better price than the lowest quoted, as there is no one to deny him. The result is that you not only bid against the others who are after the same work, but worst of all you are bidding against yourself. Your own doubts and fears and your immediate necessities are the only factors which determined how much you will shave the price. Consequently instead of one foundryman being benefitted by the transaction, the buyer is the one who walks off with the gains.

My experience in industry, especially in connection with foundries, shows me how hopelessly inadequate the present day cost practice is. I have seen patterns, machinery and tools carried as assets, which should be in the junk pile. Some foundrymen figure rent, others do not. Some figure depreciation, others do not. Some figure overhead, others do not. As for the methods of distributing an overhead, if the plans of all foundries could be put together, the result would resemble a patch quilt.

Systems Are Not Uniform

In one shop, the overhead was apportioned on a tonnage basis and it was noted that the plant was getting plenty of light complicated work but not its share of heavy work. The cost system was making the heavy work cost too much and the light work cost too little.

Men go into business to make money and to do this there must be profits. There can be no profits unless costs are less than prices. Therefore costs should be known. The accounts should show what it costs to run a business. If costs are high the system should show where they are high and why they are high. An average cost means nothing at all except that some castings cost less and some cost more. A true cost system should show how much more and how much less.

The Standard Oil Co. knows in minutest detail the cost of drilling wells, tanking, transporting oil and refining and the making of by-products. It leaves nothing to chance. The United Cigar Stores Co. never opens a store on mere estimates. Before deciding to locate in a certain a place a man with a pocket comptometer determines the number of persons who pass the spot during each hour of the day. Before opening the store, this company knows from previous statistics and experience, almost exactly the amount of business it will do and the profit it will make.

The need of costs is known to all. The trouble is that each man thinks a cost system is a fine thing—for the other fellow. We all agree to some extent that cost accounting is necessary, but there is something more important, however, than for each to have a good cost system. The basis for costs should be uniform so that all will figure along the same general lines. Even if 10 factories should put in cost systems, as complete as 10 different experts could make them, assuming that each one was different from the others, the net result to the individuals and to the industry would be worthless and time and money would be wasted.

For instance, assume that Smith says his castings cost him \$3.25; Jones replies that his castings cost \$2.75; Brown claims that his burden is 150 per cent; while Grey admits that his is nearer 200 per cent. Unless it is known just how these costs are determined, comparisons are not only meaningless, but misleading and therefore dangerous.

What do we mean by cost? Is it simply the gathering together of dry figures which are rarely used in a constructive fashion, because of the difficulty in mentally visualizing a mass

of unrelated statistics? Is cost finding to be mere history or prophecy? Is it to be used to determine what has been done in the past, without much reference to the future? Is cost compiling to be done with reference to the financial side of the business only, or is it to be of pronounced assistance to the other branches of manufacturing?

Principles to be Followed

It has been found by experience that unless four principles are incorporated in cost systems, they fall far short of performing their real functions. These principles follow:

First: A cost system to be of the greatest possible value to a business must serve the three principal divisions of the business, namely sales, production and financing.

Second: In most plants an order taken at a close margin is watched, coaxed and nursed along in the plant with the result that a profit is made or the loss kept to small proportions. Because it is definitely known what must be done, close supervision sees that it is done. Therefore, the time to see to it that a profit will be made or the loss kept to a minimum is certainly not when the work is partly finished or entirely completed, but before work is commenced. Hence it is necessary to predetermine the time and cost, and to control production so as to watch fluctuations and exceptions with a view to reducing costs, while the work is being done.

Third: If costs are abnormally high, due to operating at considerably less than capacity, prices based on such costs will mean failure to secure business. If, on the other hand, costs are abnormally low, due to night work, overtime and Sunday work, prices based on such costs will mean securing business at rates lower than you can get for your product. In other words, from the standpoint of estimating and business getting, costs can only be used to advantage as a rule when the plant is operating at or about normal capacity. By normal we mean from 80 to 90 per cent of the possible capacity of the plant. For this reason while providing for actual costs, standardization of cost rates, especially over head rates, should be arranged for in order that estimates may be more uniform and the costs made of real value to the sales and production departments.

Fourth: Cost finding should be arranged so as to make the most complicated work net the greatest returns in profit. For instance, two contracts may cost $1000 each. On one there may be $300 worth of labor, while on the other there may be only $150 worth of labor. If 20 per cent is added to the cost for profit, making the price $1200 in both cases, provision has not been made for the degree of complication. As the time of workmen and equipment are the productive investment in a business, it stands to reason that a man should get more for a job taking $300 in labor than one costing $150 for labor, and the cost keeping and price making should reflect and reconcile these differences.

Greatest use to business, predetermination, standardization and productivity constitute the principles of cost accounting. Referring to the first, "Greatest use to business," little argument should be needed to convince the manufacturer of the importance of making the system serve the three departments of the business. It is not sufficient to have a system which may be perfect from the financial standpoint, but which gives the production division of the business so little in the way of available cost data as to make it impossible for it to assist in reducing costs, nor is the cost data of assistance to the production division if the cost information is presented so long after the operation which the figures represent as to make it next to impossible for a man to remember what caused the fluctuations. Certainly there is no advantage to the sales manager if he can only rely on the cost figures when the plant is operating at normal capacity.

One of the executives of a plant once asked me to advise him on a cost problem as to which of two plans was the better. He stated that both the treasurer and the production manager wanted a cost system, but that each one wanted a different kind of a system. The treasurer wanted a financial accounting system to show his directors where the money was spent, and why, making the shops fit with his plans instead of basing his work on manufacturing conditions. The production manager on the other hand, advanced the argument that he was employed, first, to get out production as rapidly as possible, next to keep the expense down to a minimum and finally to render a proper accounting for the time and cost put in on work. In other words, the one wanted financial costs, and the other engineering costs. The one wanted to be a historian delving into the past, while the other preferred to be a prophet looking into the future. One would make cost a prime consideration of the business and the other would make it a part of manufacturing. The production manager was right.

Referring to the second principle, "Predetermination," if a careful estimate is made prior to starting the work, it offers something to aim at and enables a constant check on results during the time work is being made. Knowledge of actual costs may serve to enable a man to do better next time, but

predetermination will assist materially in keeping the cost within well defined limits. If you determine standard outputs as expressed in units per hour, in a sense you have determined the cost of work from the standpoint of time at any rate, which after all is the real productive investment in business. So long, therefore, as a job or operation is up to or ahead of the schedule of estimated production as expressed in units per working hour, the costs are bound to be within prescribed limits. What should be watched is the cost of work which falls behind schedule as here is where the losses occur. Thus, you have within your control, through the medium of predetermination, the data necessary to watch costs during the process of work and in the hands of your shop personnel, giving them a direct point of contact in connection with cost reduction. In other words, determine equivalents and watch actual results which fail to measure up to them. Do not overlook the enormous importance of the influence on shop officials in putting them in direct touch with this matter of cost, through having standard outputs and curtailing actual costs in excess of them. This does not mean that the actual costs of production are not to be compiled in an accurate manner. Predetermination should be used as much as possible in anticipating increases in cost. Watching costs in excess of estimates enables you to produce more economically than would otherwise be the case.

Normal Operation Should be Basis

Referring to the third principle "Standardization," in the early part of 1908 the writer took hold of a large plant in Pennsylvania, comprising a structural shop, machine shop and foundry. The burden accounting employed at the time gave the machine shop more profits than it was entitled to, while the structural shop was showing profits less than those actually made. The foundry was selling castings to the machine and structural shops at actual cost, which did not include any proportion of the overhead expense of the company. In the changes that followed, each department was put on its own feet through the books of the company, with provision for monthly profit and loss statements.

The theory which the author had in mind was that the greatest volume of business could be secured only when the plant was operating at about normal. With high production meaning low cost, and low production high cost, under the usual method of accounting it meant that the sales and cost divisions came into conflict both when costs were high, which operated against obtaining business, and when costs were extremely low due to abnormal business, which resulted in quoting prices lower than would be necessary to secure the business.

So much for the theory; now for the practice! A concern is in business to sell. It may make what it can sell, or sell what it makes, but selling is the fundamental basis of any business, a point which many accountants and industrial engineers seem to forget. If, as a sales manager, I cannot sell goods because due to conditions being below normal my prices are too high, or because of an abnormally high production my prices are lower than I know I can get for my goods, I don't need to be an industrial engineer nor an accountant to know that something is radically wrong with the whole thing, both in theory and in practice.

With standard rates, however, reflecting normal conditions, I am assured against loss of business on the one hand and loss in prices on the other. I know also that on this basis the line which is profitable in the shop will show profits, whereas through operating on a low production basis the increased overhead will not only wipe out the profits, but make the line show a loss. At any rate, at the time the methods were introduced in the concern in question, the business was making very little money. It's sales were not large and it was a heavy borrower, with a pattern account far in excess of real value. It had a bond issue hanging over it's head. Today this plant with two additions, is doing a capacity business, making excellent profits and declaring dividends. It is discounting its paper and has retired its bonds, while the pattern account is where it belongs.

The fourth principle is "Productivity." The most advanced doctrine of management is that the unit sold is really the time of equipment, the time of working, the time money is tied up in materials, the time of clerical help, the time of storing

materials in a given place, the time of making rigging, the time of transferring materials from one place to another, and the time of inspection. If there are delays or enforced idleness at any of these points the result will be high costs, which make for high prices. In proportion, therefore, as manufacturers consider this question of time in price making and figuring profits, in that same proportion will they increase their business efficiency.

Productivity, a Measure of Costs

It is also obvious that a customer should pay most for that which is most complicated to make. A job may be simple to mold but decidedly intricate as to core making and setting. The only basis, therefore, is to properly consider productivity, which is after all the true measure of complication.

In brief, the requirements of a proper system of foundry costing are:

Cost of labor and material should be accurately determined and properly classified.

The expenses of a business or overhead or burden as it is called, should be carefully compiled and classified.

The apportionment of overhead to production must be arranged on some basis as will not make the cost of heavy work too high nor the cost of the light work too low, otherwise the result will be loss of sales on heavy work and plenty of light work at low prices.

Those who purchase castings should pay most for those which cost the most to produce, as reflected by the time taken to produce them.

Costs vary with productivity by which is meant the relative amount produced per man per day. The work of a man producing a ton per day costs less per 100 pounds than that of a man who produces only 500 pounds per day and the cost should reconcile this difference. In other words, consideration should be given to the fast and slow moving jobs.

Costs should be classified according to whatever plan will best meet the particular conditions. This can be done according to classes of work, kind of molding, separate patterns and classes of patterns, kind of cores, character of cleaning, according to departments, and by classified weights. Provision in all cases should be made for determining the cost of individual patterns.

Costs should be placed on a 30-day basis offering 12 opportunities per year for locating and correcting faulty conditions.

Costs should be based on standard rates for the various items in order to enable a foundry to operate and make prices based on normal conditions.

With the four principles incorporated in the cost system, and the eight requirements met, the following may be expected:

1. Elimination of guess work in price making
2. Knowledge that all items are included.
3. The right kind of a basis for predetermining production rates and costs.
4. Intelligent apportionment of overhead.
5. Comparison of work between different plants.
6. Close watch on work running over estimates.
7. Discouragment of price cutting.
8. Better prices.
9. Stronger institutions financially.
10. Valuable Association data.
11. Betterment to the entire industry.

The *Bridgeport Evening Post* on Aug. 13 made the following statement editorially:

"The master printers of this country have a constructive organization from which other industries and trades can well take the idea. Instead of being an organization to control prices and for fighting the labor unions, it is one to work with each other as to costs. There was a great deal of piratical competition in the printing industry. Some customers paid too much and others not enough. One department in a plant would make money and the other lose it. Various attempts were made in the past to form organizations among master printers to control prices, which also served for warfare on labor unions."

"The real constructive idea of this printers trade organization and which has been found to be successful, is that if a printer knows his cost he will not sell his product for less than its cost and thereby he does not become an unfair competitor to his neighbor. Therefor nothing is said or done in the matter of sales prices."

Conclusion

In presenting this argument more attention has been paid to principles, laws and economic considerations than to the methods and forms, which after all are only incidental considerations. If the basis is right, the factors having to do with gathering and compiling cost data are easily within the control of any competent cost accountant or accounting organization.

In closing, therefore, let me repeat that a cost accounting plan must have as much to do with the future as with the present or past. It must serve the production and sales departments of the business just as much as the financial. It must know as much about what should be done as what is being done. If designed to give due consideration to the factors enumerated it will serve you well in this day of keen competition, tax complications and labor difficulties.

Report of the A. F. A. Committee on Foundry Costs

During the year since the last report of your committee on foundry costs, showing condition of work done and financial status up to Sept. 1, 1918, the work has been prosecuted vigorously.

It was found by C. E. Knoeppel & Co., after visiting a number of the subscribers' plants, that some changes in the method of presentation would be advisable, in the interest of simplicity. They therefore prepared a new bulletin to supersede the original one and at a meeting of your committee, March 5, 1919, the new presentation was passed upon and accepted. After duplication, copies were mailed to all subscribers and all were requested by mail to thoroughly digest them.

During July an itinerary was arranged which included a number of revisits to plants already visited.

Since that time the work of visiting clients has progressed satisfactorily, and it is anticipated that by the end of the current year the work will have been completed.

Of the foundries visited 90 per cent have been convinced and have agreed to go ahead with the installation of the standard system. The balance have agreed and will go ahead ultimately. It is with satisfaction that your committee reports this condition.

The following is a summary of work done and to be done as of Sept. 5, 1919:

Foundries visited	18
Foundries to visit	57
Foundries not heard from	24
Visits not desired	6
Not using system	9
Not interested	9
Out of bounds	3
	126

A number of requests were received by the secretary inquiring as to the possibility of individuals and organizations getting data from your committee for similar work and in order to discuss this phase of the matter thoroughly a meeting was called and held Sept. 3, 1919, at the William Penn hotel, Pittsburgh, and attended by Messrs. A. O. Backert, president of the association; J. Roy Tanner, chairman of your committee; H. J. Koch, C. H. Gale, G. D. Piper and J. P. Jordan of the C. E. Knoeppel Co.

Report to be Printed

After a thorough discussion the following action was taken: "Moved and seconded, that this committee recommend that the cost report be printed and made part of the proceedings of the association, and that a separate volume be published for wider distribution by sale, and that the subscribers who have underwritten the system, and thus performed a valuable service to the industry, dedicate their work to the industry as a guide to better cost keeping, subject to variation depending upon the size of plant and peculiarity of product."

It was fully understood that all service to subscribers would be carried out as agreed, and Mr. Jordan for C. E. Knoeppel & Co. stated that that company would waive all claims for royalties.

In making this recommendation the committee recognizes that some of its members had ideas slightly at variance in some of the details of allocating overhead to weight, or time, but in general the principles of the system are sound.

It is requested that the American Foundrymen's association take such action as will enable the secretary to take up with the subscribers the question of presenting their work to the association, and also, if necessary, to authorize the inclusion of the system in the proceedings for the year 1920.

We will thus give our work an official standing which can be secured only through the approval of a large technical society, and which will be, we believe, of great value in influenc-

ing for uniformity, the work of other bodies along the same lines.

Data on the financial operations of the cost committee are included in the report of the secretary-treasurer.

C. R. MESSINGER,
H. J. KOCH,
C. H. GALE,
G. D. PIPER.
J. ROY TANNER, *Chairman.*

Discussion

PRESIDENT A. O. BACKERT.—The cost system question has been before the members of the association for several years. The cost of the system together with the service of one of the cost experts to visit the plants of the subscribing companies ranged from $50 to $250. Now it is felt, and the members of the cost committee are of the opinion that the subscribers to that system have done pioneering work of great value to the foundry industry of the country; that foundrymen generally should install cost systems and that these subscribers might not object to letting the entire foundry industry have the benefit of that cost system. It therefore was recommended by the cost committee that this cost system be printed in the bound volume of the proceedings and also be printed separately in book form so that it may be available to cost clerks, auditors, etc., in that shape. The C. E. Knoeppel Co., which was employed to prepare and install this cost system, raised no objection to it whatever and agreed to waive all royalties. It is the recommendation of this cost committee that the cost system be printed as a part of the bound volume of the proceedings, and also be printed separately. Before doing so, however, it is deemed advisable to ascertain from the subscribers just exactly how they feel about it.

MR. P. H. GARTLETT.—I make that motion.

The motion was seconded by Tom Tannenbaum and carried.

Cost Accounting System—American Foundrymen's Association, Inc.

In presenting this revision of the original bulletin on the cost accounting system no attempt is made to provide for all possible forms used in handling the various lines of routine of the general business operations. It is assumed that all companies have adequate purchasing and commercial accounting systems which would bring all purchases of materials, labor and expense items to certain prescribed ledger accounts, and that adequate invoicing methods are in vogue for sales. Only such documents as are actually necessary for the accounting of the costs will be mentioned in this bulletin in order to simplify the presentation.

Plan of the System

The plan of costs shown herewith is simple and is briefly outlined as follows:

The scheme really consists of three main stages:

First:

The proper distributing of purchases of material, labor and miscellaneous expense items to certain proper control accounts subject to further accounting by requisition, time cards, etc., to the proper cost accounts.

Second:

(a) The proper accounting of the use of materials, labor, etc., to productive and expense orders, and the transfer of same by summarized monthly journal entries, to the cost control accounts.

(b) Also the transfer from the cost accounts of metal and overhead accounts of the proper cost amounts at predetermined rates to the work in process account by journal entry.

Third:

The compilation of costs of product, which, summarized for the month, credit the work in process and charge sales cost by journal entries.

Predetermined Rates

Before proceeding further it should be perfectly clearly defined in each mind the meaning of "predetermined rates."

In foundry costing particularly, the feature of predetermined rates is by far the greatest feature. Metal cost must be by pound of metal poured; molding and core burden by percentage on direct labor by each department; finishing cost by

percentage on molding and core direct labor combined; annealing cost by pound on good castings, etc., etc.

But even though we find the actual cost of each of the preceding monthly, it is absolutely improper, unfair and really impossible to use the actual figures of any one month or small group of months in the figuring of costs.

Take, for instance, the cost of melting. Last month we operated smoothly with no repairs of any great amount. This month quite a bit of brick repairs were necessary. Then suppose that next month something went wrong with the blower and we had a very heavy cost of repairs in damages done the cupola. In open-hearth furnaces this feature is very pronounced, as 300 heats may slide along smoothly and then start troubles resulting finally in a complete tear down to the checkers. Or perhaps even the checkers are plugged up.

The same applied in perhaps less extent in all the burden and pound cost accounts.

It is apparent, therefore, that no one month's cost can fairly be taken. Nor even a small group of months. In fact, to be nearest safe, the average of a complete year and even more should be taken as the rate to be used in both estimates and actual costs, for each of the divisions mentioned in the second paragraph.

Bear in mind, however, that the actual cost of each rate is found each month, and in such detail that steps can be taken to study and improve the operating methods in order to make the average or predetermined rate good. In fact, the constant goal should be to beat it and make money by so doing.

Arriving at Predetermined Rates, Burdens and Pound Costs

In melting cost, molding burden-direct labor and all such cost accounts distributed by percentage and pound rates, the basis should be arrived at by using figures of expense and the basis the expense is figured on of at least a year's operation. Of course in starting new, this will be difficult; but this should be the aim.

Machine Hour Rates

In arriving at the predetermined rate per hour of the

molding burden-machine hour, and the coremaking burden-machine hour, a little different procedure holds. Similarly to the preceding accounts, find as closely as possible the maintenance charges covering at least a year of all the machines the time of which is to be charged for; that is, all in the molding department in one group, and all in the core in another group. Then arrive at the total power charge for each group. Finally, assemble the proper depreciation for each group. All three of these items will of course be figured by each machine which enters into each group.

Next, compute the total machine hours possible, which is the number of normal working hours of your plant times the number of machines in each group. Then take 85 per cent of the total possible hours in each group as the basis of your rate. Finally divide the total cost for the period by the 85 per cent of total possible hours, thereby arriving at the standard rate to use.

In regular monthly working, it will be best to use the actually employed machine hours as the basis of monthly costs, as shown by the cost statements.

Cost Plan in Greater Detail

In more detail, the cost scheme deals with the subject as follows: The headings shown being those which appear on the cost sheet whereon the cost of a casting or classes figured.

Direct Labor is charged to production orders which represent either individual patterns or classes of work. This labor consists only of that which is directly chargeable to the product manufactured. All other labor entering into pound or percentage rates is classed as indirect labor.

Metal Cost is assembled monthly in a melting cost account. This account is credited with the actual metal poured at the predetermined rate, the balance showing whether operating over or under the proper rate.

Molding Burden—Direct labor is assembled monthly in the molding burden account, which account is credited at close of month with the amount of burden represented by the predetermined percentage of the actual direct molding labor for the month. The balance indicates whether operating over or under the required rate.

Molding Burden-Machine Hour is assembled monthly in the molding burden-machine hour account, and is credited at close of month with the amount represented by the actual number of machine hours consumed for its month on productive work at the predetermined rate per hour. This predetermined rate is designed to be figured on the basis of a long average cost of items shown

in the detailed directions later, divided by 85 per cent of the total possible machine hour of the equipment.

The balance remaining indicates whether operating above or below the required rate.

Core Burden-Direct Labor is assembled monthly and is treated same as molding burden except that core direct labor is the basis for percentage.

Core Burden-Machine Hour is operated for machine equipment for core department, exactly the same as for molding department.

Molding Sand Expense
Flask Expense—These two costs will in most cases be a part of the molding burden and are so shown here. But in steel plants particularly, they may be treated as separate costs, and are so arranged for in detailed expense classification. If so, they will be entirely eliminated from the molding burden, and a separate cost statement made for each. In this case the basis of predetermined rate for molding sand will be metal poured, and flask expense will be on basis of good castings.

Finishing Cost is assembled monthly and is treated same as molding and core except that combined molding and core direct labor is the basis for percentage.

An exception to this is in plants large enough to treat direct operations in this department as direct labor, in which case its own direct labor charged to production orders will become the basis for distribution of its burden, same as in molding and core departments.

Annealing Cost is assembled monthly in an account of same name, which account is credited with amount represented by number of pounds good castings at the predetermined rate per pound. The balance indicates whether operating over or under the required rate.

It might be stated here that the real correct basis for this cost should be the weights of castings *annealed* rather than the basis of total good castings produced. Those who will tally the castings annealed will get far more accurate costs by so doing, as this eliminates castings not annealed and brings in castings re-annealed as is often the case.

Actual Cost Sheet (also as estimate sheet). In order to assist in understanding the details following, it is suggested that at this point, immediately after reading the preceding pages, a study be made of the actual cost sheet data shown under Section V, "Cost Compilation." This will aid very much in understanding the details leading up to the costs and cost statements as shown.

Form of Presentation

The presentation of the methods following is divided into sections, each section representing a particular phase.

SECTION I
MATERIAL ROUTINE

Material accounting presents no particular difficulties due, probably, to the fact that it deals with tangible things and that practically all transactions are directly traceable as used for a particular purpose or as benefiting a particular department.

The material forms principally required for costkeeping purposes are:

1. Stock ledger (card or sheet).
2. Material requisition.
3. Material credit memorandum.

1. *Stock Ledger*—The stock ledger should be a complete record of each item of material showing quantity required, ordered, received and issued, and the unit and total value of such material.

Material accounts should be maintained in the general ledger representing at closing periods the value of materials on hand supported by the details of the stock ledger sheets or cards, which form a detailed analysis of each control account.

2. *Material Requisitions*—Material withdrawn from stock must be accounted for in the following manner, all requisitions, etc., showing clearly the use of, and order number chargeable with the materials used:

Melting Materials—Cupola or Furnace Reports

The furnace or cupola reports, made out daily by the weigher or storeskeeper, give the quantity and kind of melting and fuel materials used, and the account numbers to be charged. From these reports the stores ledger is posted and the unit prices thereon are noted on the furnace reports and the amounts derived.

The furnace reports may then be sent to the cost department to serve as the basis for the charges, each month, to the expense accounts involved, or instead, classified material requisitions may be made up monthly and sent to the cost department.

Miscellaneous Materials

All material not included on the furnace report should be the subject of a material requisition made out at the time of withdrawal of material from stock. The course of the material requisition is as outlined above. The disposition of the requisition and the charges it carries will be treated of presently.

Recovered Material

Recoveries of over-iron, shot, spills, etc., should be shown on the daily cupola or furnace report.

3. *Material Credit Memoranda*—Material credit memoranda simply reverse the charge made on material requisitions and represent unused material being returned to stock for which corresponding credit must be given.

Note:—As far as possible all material should be kept in a neat orderly manner in well regulated stock rooms. Otherwise, it is exceedingly difficult to enforce requisition regulations.

Also all issuances of material should be accounted for with accuracy. Pig iron, scrap, and all materials should be carefully weighed; it is little use to run a cost method on guessed quantities.

Entering, Pricing and Recapping Requisitions, Etc.

As requisitions for materials used are received by cost department, they will be entered on stock ledger, and priced and extended at the unit values shown on stock ledger.

Before filing under order numbers, the requisitions representing material drawn from each separate material control account should be added each day, and the total withdrawals for each control account entered on an accumulation sheet to run for the current month. The totals for the month of this accumulation sheet become the credits to the material control accounts in the monthly journal entry of distribution of materials. The debits of this entry are to the various expense accounts as described later.

Expense Ledger Charge Slips

Under "Expense Routine" is described in greater detail the use of the expense ledger charge slip, which in a large measure is like a material requisition, except that it charges material or service charges direct from the purchase entry to the expense accounts. This covers a large class of charges of intangible and evasive nature which are not properly or safely run through regular stock material accounts subject to requisition.

SECTION II

LABOR ROUTINE

Labor accounting has two main elements—payroll compilation and labor distribution. Payroll compilation is comparatively simple, if the time has been correctly reported and recorded. Payroll compilation is merely the weekly summarizing of the wages earned by each employe daily. Labor distribution is the correct apportionment of wages against production orders or classes (direct labor) or expense accounts (indirect labor). The chief difficulty is in the incorrect reporting of applied time by the men, faulty counting or reporting by the inspectors, incorrect scale reports and clerical errors by the timekeepers. As many safeguards as practicable should be adopted to insure the correct reporting of time, accurate counting and inspection reports and accurate clerical operation in the transcription of data.

The labor forms principally required for cost keeping purposes are:

1. Daily time ticket.
2. Payroll sheet.

1. *Daily Time Tickets*—The time tickets should be used to report the time spent on the various kinds of work performed. Only one job, either direct or indirect, should be on one time ticket. This is so that the time ticket may be filed under its order number, whereby the actual original entry becomes our cost entry.

The time tickets should provide the following information:

Order number, pattern number, name of operation or work performed, machine number on which work performed, quantity completed, piece or hourly rate, elapsed time, wages earned, man number, and date.

In keeping time it should and must be verified daily that the total time represented by the time tickets agrees absolutely with that shown by the in-and-out clock cards rung by each man, which usually are the regular weekly card.

The daily time tickets are filed by order numbers after entry on payroll as described immediately following:

2. *Pay Roll Sheet*—The pay roll sheet, a weekly sheet for each man, should perform two functions:

First:—Collate the pay of each man for week.

Second:—So enter the time cards, that a controlling distribution is made as between direct and indirect labor for the purpose of

(a) In the case of direct labor, give us the amount for each department as the basis of our journal entry, and

(b) In the case of indirect labor to give us a total which *must be equalled* by the total of the indirect labor in the various monthly expense and burden statements as explained later, and which will complete the journal entry of the distribution of labor.

The pay roll sheet, therefore, should be so arranged as to have columns approximately as follows:

Day of month
Slip number
Order Number
Direct labor (main heading)
Hours
Amount
Indirect labor (main heading)
Hours
Amount
Total (main heading)
Hours
Amount

Additions of bonus, etc., or deductions of any nature will be made at close of week at bottom of sheet.

* * * * *

It is important to fully understand at this point that direct labor is only that which may be *directly* charged to the product being manufactured—such as molding and coremaking labor. In some large foundries, especially steel, the finishing operations of chipping, grinding and the like may better be handled as direct labor, but never where only part of it can be charged directly to the product. Melting and annealing labor and the like are only chargeable to the product through a pound or percentage method; therefore, this class of labor can only be classed as indirect labor.

* * * * *

Labor Distribution

As stated before, the distribution as between direct and indirect becomes our most valuable control of further entries. The making up of the expense and cost accounts described in Section III depend on the totals as shown herewith for proof of accuracy.

There being a pay roll sheet for each man for each week we have three points to handle to arrive at our proper results:

First:—To arrive at total plant pay roll, add by adding machine (or draw off on recap sheet) for the week:

(a) Total direct labor.
(b) Total indirect labor.
(c) Total pay for week.

This should be done by producing departments (melting, molding, core, etc.). This gives us the direct labor for the departments where same applies for the week covered by the pay roll.

Second:—Where a week straddles the end of a month, the pay roll sheet of each man has to be sub-totaled or split, in order to arrive at the actual earned pay roll for the days belonging in each separate month.

Third:—The totals of direct, indirect and total pay for each week and portion of week, for each given month must be recapped, which then gives us the monthly totals of each, separated into each producing department.

We now have our control figures of direct, indirect and total earnings for the month. The total direct for each department is our basis for transfer from pay roll account to work in process, and also the basis for crediting the operating burden accounts with the proper amount of burden for each department at the predetermined rates used, charging work in process. (See journal entries.)

SECTION III

EXPENSE ROUTINE

Expense accounting deals with those disbursements which contribute to and are necessary in connection with the production of salable merchandise but which are not apparent or directly traceable in the finished product; includes labor performed not directly traceable on the finished articles; includes expense materials consumed in the processes of production; includes all expenditures for maintenance of property, buildings and equipment; also small tools and supplies, insurance, taxes, depreciation, power, heat and light.

On account of the fact that the indirect costs are applicable to the cost of the product in various ways, a brief explanation of same is here made:

Melting Cost is distributed on the basis of cost per pound of metal poured. It is evident that the quantity of metal used in pouring a mold, including the casting itself and all sprue is the correct basis of the charge—at the pound rate—to that casting.

Molding Burden-Direct Labor is distributed by percentage on the direct molding labor, this being the most generally accepted manner of distributing this expense.

Molding Burden-Machine Hour is distributed on the basis of predetermined cost per hour, it being the natural method to charge for the use of machine equipment on the basis of the time it is used.

Core Burden-Direct Labor is on same basis as molding except, of course, being on direct coremaking labor.

Core Burden-Machine Hour—Same idea as in molding.

Molding Sand Expense (if used separately from being a part of molding burden) is distributed on the basis of metal poured. This is on account of the fact that the contact of metal is the regulating factor of destruction of sand, therefore total poured is the basis.

Flask Expense (if used) is on the basis of cost per pound of good castings produced.

Finishing Cost is distributed on basis of molding and core direct labor combined for the reason that molding direct labor represents the "outside" and the core direct labor the "inside" work necessary to properly clean the casting. This therefore, allocates greater finishing expense to cored castings as is proper.

Annealing Cost is distributed on basis of good castings, as there is the existing record of such basis. However, if one will, the even more correct basis should be that of castings actually annealed, although the basis of good castings is near enough correct in the majority of cases.

* * * * * *

The preceding appear in the compilation of any casting or class plant cost. The following are expenses which, after being collected are apportioned or split down to the operating expense accounts.

Apportioned Expenses

Power, Light and Heat Expense is apportioned to the various operating expense and burden accounts on the best basis possible as representing the actual benefit received by each department. Metered consumption is of course best; estimates on basis of horsepower of motors, wattage of lamps for light charges, floor space for heating, etc., are next best, and the usual way.

Pattern Expenses are apportioned to the molding and core burden accounts on the basis of actual benefits received as explained in the detail directions.

General Expense is apportioned to the operation expense and burden accounts on the basis of the total labor cost, direct and indirect, of each operating department. For instance, the total direct labor plus the total indirect labor charged to expense orders in the molding department would be its basis; i. e., such a per cent of the general expense as its cost is of the total of all the departments.

Miscellaneous Items are apportioned to the operating expense and burden accounts according to the nature of the item. (See under Group 8 following.)

* * * * * *

All possible expense should be charged directly to one of the operating expense or burden accounts. Where impossible the general expense, power light and heat expense, etc., are to be used.

The items entering into each of the operating expense and burden accounts, and into the general accounts are clearly shown in the following pages. All charges come from time tickets, requisitions, etc., all of which must bear the expense code order number to which they belong.

Certain charges which are best made directly from the entry of a purchase are handled by the *expense ledger charge slip,* which shows date, account charged, amount of charge, date of invoice and description of what is charged. An invoice for such material is charged in the purchase register to "expense ledger account," showing therewith the proper expense order number. An expense ledger charge slip is made out at same time, which slip is same size as material requisition. This slip is sent to cost department, who file same with proper order number same as a requisition. When costs are figured for month, the

total of the expense ledger charge slips appearing in the various cost statements *must equal* the total of the expense ledger column in the purchase register for the same month. This is explained further under "Cost Compilation."

If any foundry installing their methods are only a unit of a larger business, some method will necessarily be required to get charges for service to the foundry accounts in a manner to be checked up in some such manner as if the foundry department were a separate business.

Expense and Burden Accounts

In order to have an analysis of what makes up each expense and burden account for purposes of constant check on the expenditures of money, there follows a set of analytical expense orders, grouped in the necessary divisions for cost figuring.

The items shown may be changed to suit any plant; may be increased or decreased in number; but under no circumstances should any foundry attempt to do business without a fairly complete analysis along the lines shown.

These expenses are grouped as has been previously shown, but for reference are as follows:

LABOR **MELTING EXPENSES** **GROUP 1**

101—FOREMEN AND ASSISTANTS.

All amounts paid for services of general or supervising foreman.

102—TIMEKEEPERS AND OTHER CLERKS.

Salaries or wages of timekeepers or other clerks located in this department; includes, also, prorata amount of salaries or wages paid to timekeepers or other clerks serving this and another department.

103—UNLOADING MELTING MATERIALS.

Wages paid for unloading cars or boats containing melting materials if a short term or normal supply. If exceptional quantities are obtained for long term storage, the labor

expense should be added to the invoice cost as are freight charges and disbursements charged accordingly.

104—CUPOLA OR FURNACE LOADERS.

Wages paid men for loading cupolas and oil furnaces and open-hearth steel furnaces, also melters at small pots for making crucible steel.

105—ELEVATOR AND CRANEMEN.

Wages paid for operating elevators and cranes in connection with handling melting materials.

106—BREAKING SCRAP.

Wages paid for breaking up scrap or otherwise preparing scrap for use in cupola or furnace.

107—HANDLING SLAG.

Wages paid for handling and removal of slag, collecting over-iron, shot, spills, etc.

108—TESTING MATERIALS AND PRODUCT.

All amounts paid laboratory employes engaged in analysis and test of melting materials and foundry product.

109—MELTING MATERIALS STORES LABOR.

Wages of men engaged in moving melting materials from storage areas to charging platform, excepting services of elevator and crane men.

110—SICKNESS AND ACCIDENT RELIEF.

Wages paid to employes absent on account of sickness or accident. Allowance must be approved by Superintendent.

111—GENERAL LABOR.

Wages paid to miscellaneous general labor not provided for in this classification.

112—..

113—..

MAINTENANCE OF PROPERTY.

121—BUILDINGS.

Labor and material used in repairing or partially renewing buildings or structures.

122—CUPOLAS OR FURNACES.

Labor and material used in repairing or partially renewing cupolas and furnaces; also their equipment for draft and circulation of air, as well as foundations.

123—CONVERTERS.

Labor and material used in repairing or partially renewing converters.

124—ELEVATORS, CRANES AND CONVEYORS.

Labor and material used in repairing or partially renewing elevators, cranes, conveyors, transfer tables, etc.

125—ELECTRICAL APPARATUS.

Labor and material used in repairing or partially renewing all electrical apparatus.

126—PIPE AND POWER LINES.

Labor and material used in repairing or partially renewing all piping, plumbing and electrical wiring inside of buildings, including drainage and sewer pipes, water, gas, air and oil pipes and their fittings; cables and wires for power and lighting circuits, including wiring devices.

127—PLATFORM AND STAIRWAYS.

Labor and material used in repairing or partially renewing charging platform and stairway.

128—..

129—..

130—..

SUPPLIES

141—ALUMINUM.

142—BRICK.

143—CLAY.

144—COKE.

145—ELECTRODES.

146—FUEL OIL.

147—LIME.

148—LIMESTONE.
Self-explanatory.

149—LINING MATERIALS.
All miscellaneous lining materials used in the upkeep of ladles, stoppers, spouts, etc.

150—SAND.
Self-explanatory.

151—MISCELLANEOUS SUPPLIES.
Miscellaneous materials not otherwise provided for in this classification.

152—LABORATORY EXPENSE.
Expenditures in connection with the laboratory other than salaries or wages which are chargeable to Account No. 108.

153—..

154—..

155—..

MOLDING BURDEN—DIRECT LABOR GROUP 2

LABOR

201—FOREMEN AND ASSISTANTS.
All amounts paid for services of general or supervising foremen.

202—TIMEKEEPERS AND OTHER CLERKS.
Salaries or wages of timekeepers or other clerks located in this department; includes, also prorata amount of salaries paid to timekeepers or other clerks serving this and another department.

203—CUTTING SAND AND PREPARING FLOORS.
Wages paid for cutting sand and otherwise preparing the floors for molders.

204—CLOSING AND CLAMPING MOLDS.
Wages paid for all labor engaged in closing and clamping molds.

205—DRYING MOLDS.
Wages of men operating drying ovens in connection with dry sand molding, both firing the ovens and drying the sand.

206—RUNNER CUPS.
Wages of men engaged in making runner cups or boxes.

207—BROKEN MOLDS.
Wages of men engaged in repairing and finishing broken molds.

208—CARRYING PATTERNS AND FLASKS.
Wages of men engaged in carrying patterns and flasks to and from storage.

209—POURING.
Wages of men engaged in work of pouring.

210—SHAKING OUT.
Wages of men engaged in shaking out castings.

211—TAKING OUT REFUSE AND SCRAP.
Amounts paid for taking out and disposing of refuse and delivery of scrap.

212—CLEANING AND SWEEPING.
Amounts paid for services in sweeping, raking or otherwise cleaning the department.

213—CRANE OPERATOR.
Wages paid for services of cranemen in the department operations.

214—IDLE TIME.
Wages paid men for idle or unapplied time, and reason for the charge must always be given. Does not include allowances for sickness or accident.

215—SICKNESS AND ACCIDENT RELIEF.
Wages paid to employes absent on account of sickness or accident. Allowances must be approved by the Superintendent.

216—PATTERN STORAGE LABOR.
Wages of men engaged in receiving, storing and laying out patterns and core-boxes.

217—EXPENSE DUE TO ERRORS AND DEFECTS.
Expenses or losses due to errors of department employes whether mechanical or clerical, as for example; breakage, spoilage, misplacement or careless shop work of any kind.

218—GENERAL LABOR.

Wages paid to miscellaneous general labor not provided for in this classification.

219—..

220—..

MAINTENANCE AND SUPPLIES.

221—BUILDINGS.

Labor and material used in repairing or partially renewing buildings or structures.

222—MOLDING MACHINES. (Omit if Machine Rate used.)

Labor and materials used in repairing or partially renewing all molding machines other than jarring.

223—JARRING MACHINES. (Omit if Machine Rate used.)

Labor and material used in repairing or partially renewing all jarring machines.

224—AIR HOISTS.

Labor and material used in repairing or partially renewing all air hoists.

225—CRANES.

Labor and material used in repairing or partially renewing all cranes.

226—ELECTRICAL APPARATUS.

Labor and material used in repairing or partially renewing all electrical apparatus.

227—SHOP FIXTURES.

Labor and material used in repairing or partially renewing all shop fixtures such as benches, racks, bins, lockers, railings, etc.

228—PIPE AND POWER LINES.

Labor and material used in repairing or partially renewing all piping, plumbing, and electric wiring inside of buildings, including drainage and sewer pipes, water, gas, air and oil pipes and their fittings; cables and wires for power and lighting circuits, including wiring devices.

229—SMALL TOOLS.

Labor and material used in repairing or partially renewing all small tools within the department which have a comparatively long term of usefulness; such as portable pneumatic rammers, chain hoists, screw or hydraulic jacks, hand trucks, chain and rope tackles, etc.

230—GAGGERS, CHILLS, CHAPLETS AND BOLTS.

231—NAILS.

232—LAMP BULBS.

Names of supplies—self explanatory.

233—PATTERNS.

Labor and material used in the alteration and repair of patterns shall be accumulated under Account 702 and shall be transferred monthly to this account. Account 702 is a memorandum account only to be used as a basis in the apportionment of the Pattern Department expenses as described under account 702.

234—MOLDING SAND EXPENSE.

Expenses in connection with molding sand cost are such an important element in the operating of the Molding Department that provision is made herein for the directly traceable factors of molding sand cost which may be summarized as a separate schedule, if desirable, and so reported.

The following sub-accounts shall be used:

234—1 MOLDING SAND.

Cost of molding sand used during the month (i.e. invoice price plus transportation charges)

234—2 UNLOADING MOLDING SAND.

Wages paid for unloading cars or boats containing molding sand if a short term or normal supply. If exceptional quantities are obtained for long term storage, the labor expense should be added to the invoice cost as are freight charges and disbursement charged accordingly.

234—3 MIXING MOLDING SAND.

Wages of men engaged in mixing molding sand including preparation and wheeling.

234—4 MAINTENANCE OF MIXERS.

Labor and material used in repairing or partially renewing sand mixers.

234—5 MISCELLANEOUS SUPPLIES.

All incidental and miscellaneous supplies not otherwise provided for in this classification.

234—6 MISCELLANEOUS EXPENSES.

All other incidental and miscellaneous disbursements not provided for in this classification.

Molding sand cost, if reported as a separate factor, should be liquidated at a cost per pound of metal poured, or, else, included in the departmental burden and those combined in the departmental percentage on direct labor.

235—FLASKS.

Expenses in connection with flask cost are also such an important element in the operating of the molding department that provision is made herein for the directly traceable factors of flask cost which may be summarized as a separate schedule, if desirable, and so reported. The following sub-accounts shall be used:

235—1 WOOD FLASKS AND BOTTOM BOARDS.

Labor and material used in making (unless for special orders) repairing or replacing wood flasks or bottom boards shall be accumulated under Account 704 and shall be transferred to this account. Account 704 is a memorandum account only to be used as a basis in the apportionment of the pattern department expenses as described under Account 704.

235—2 SNAP FLASKS AND JACKETS.

Labor and material used in repairing or partially renewing snap flasks and making new or replacing old wood jackets shall be accumulated under Account 705 and shall be transferred to this account. Account 705 is a memorandum account only to be used as a basis in the apportionment of the pattern department expenses as described under Account 705.

235—3 METAL FLASKS.

Labor and material used in repairing or partially renewing all metal flasks.

235—4 FLASK PLATES.

Labor and material used in repairing or partially renewing all flask plates.

236—NONDURABLE TOOLS.

Cost of repairing and renewing all tools and equipment of a nondurable nature and classed as a miscellaneous shop supply. This account is intended to cover mainly those classes of portable tools which are short lived and comparatively inexpensive. All current expenditures for non-durable tools should be distributed to this account whether such expenditures represent initial cost of additions or replacements of the nondurable tool equipment.

237—METAL ARBORS AND CORES.

Labor and material used in repairing or partially renewing all metal arbors and cores.

238—MISCELLANEOUS SUPPLIES AND EXPENSES.

Incidental and miscellaneous disbursements not otherwise provided for in this classification.

239—..

240—..

MOLDING BURDEN—MACHINE HOUR **GROUP 3.**

251—MAINTENANCE OF MOLDING MACHINES.

Labor and material used in repairing or partially renewing all molding machines other than jarring machines.

252—MAINTENANCE OF JARRING MACHINES.

Labor and material used in repairing jarring machines.

COREMAKING BURDEN—DIRECT LABOR. **GROUP 4.**

LABOR.

301—FOREMEN AND ASSISTANTS.

All amounts paid for services of general or supervising foremen.

302—TIMEKEEPERS AND OTHER CLERKS.

Salaries or wages of timekeepers or other clerks located in this department; includes

also prorata amount of salaries or wages paid to timekeepers or other clerks serving this and another department.

303—INSPECTING CORES.
Wages of Inspectors engaged in the inspection of cores.

304—UNLOADING CORE SAND.
Wages paid for unloading cars or boats containing core sand if a short term or normal supply. If exceptional quantities are obtained for long term storage the labor expense should be added to the invoice cost and freight charges and disbursement charged accordingly.

305—WHEELING AND MIXING CORE SAND.
Wages of men engaged in mixing core sand including preparation and wheeling.

306—UNLOADING AND TENDING OVENS.
Wages of men operating drying ovens in connection with baking cores, including firing the oven.

307—HANDLING CORES.
Wages of men engaged in handling cores to and from storage.

308—REPAIRING CORES.
Wages of men engaged in repairing defective cores.

309—CRANE OPERATOR.
Wages paid for services of cranemen in the department operations.

310—STORING CORES.
Wages of men engaged in receiving, storing and laying out cores.

311—SICKNESS AND ACCIDENT RELIEF.
Wages paid to employes absent on account of sickness or accident. Allowance must be approved by the Superintendent.

312—EXPENSE DUE TO ERRORS AND DEFECTS.
Expenses or losses due to errors of department employes whether mechanical or clerical, as for example; breakage, spoilage, misplacement or careless shop work of any kind.

313—GENERAL LABOR.
Wages paid to miscellaneous general labor not provided for in this classification.

314—...

315...

MAINTENANCE AND SUPPLIES.

321—BUILDINGS.
Labor and material used in repairing or partially renewing buildings and structures.

322—COREMAKING MACHINES. (Omit if Machine Hour Rate Used.)
Labor and material used in repairing or partially renewing all coremaking machines.

323—SAND MIXING MACHINES.
Labor and material used in repairing or partially renewing core sand mixing machines.

324—ELECTRICAL APPARATUS.
Labor and material used in repairing or partially renewing all electrical apparatus.

325—CORE OVENS.
Labor and material used in repairing or partially renewing all core ovens.

326—SHOP FIXTURES.
Labor and material used in repairing or partially renewing all shop fixtures, such as benches, racks, bins, lockers, railings, etc.

327—PIPE AND POWER LINES.
Labor and material used in repairing, or partially renewing all piping, plumbing and electric wiring inside of buildings, including drainage and sewer pipes, water, gas, air and oil pipes.

328—CRANES.
Labor and material used in repairing or partially renewing all cranes.

329—PLATES.
Labor and material used in repairing or partially renewing all core plates.

330—SMALL TOOLS.

Labor and material used in repairing or partially renewing all small tools within the department which have a comparatively long term of life.

331—CORE BOXES.

Labor and material used in the alteration and repair of core boxes shall be accumulated under account 703 and shall be transferred monthly to this account. Account 703 is a memorandum account only to be used as a basis in the apportionment of the Pattern Department expenses as described under account 703.

332—FUEL CONSUMED.

Includes the cost of all fuel used in the core ovens.

333—CORE SAND.

334—CLAY.

335—CORE COMPOUND AND OIL.

336—FLOUR.

337—SILICA WASH.

338—RODS, WIRES, NAILS.

Names of supplies—self explanatory.

339—MISCELLANEOUS SUPPLIES AND EXPENSES.

All incidental and miscellaneous disbursements not provided for in this classification.

340—..

341—..

COREMAKING BURDEN—MACHINE HOUR **GROUP 5.**

351—MAINTENANCE OF COREMAKING MACHINES.

Labor and materials used in repairing coremaking machines.

FINISHING COST **GROUP 6**

LABOR.

401—FOREMEN AND ASSISTANTS.

All amounts paid for services of general or supervising foremen.

402—TIMEKEEPERS OR OTHER CLERKS.

Salaries or wages of timekeepers or other clerks located in this department; includes also, prorata amount of salaries or wages paid to timekeepers or other clerks serving this and another department.

403—INSPECTORS.

Wages of Inspectors engaged in departmental inspection work.

404—CRANE OPERATORS.

Wages paid for services of cranemen in the departmental operations.

405—HANDLING GOOD PRODUCT.

Wages for handling good product in finishing department and piling good castings in storage areas.

406—TAKING OUT REFUSE AND SCRAP.

Wages paid for collecting and disposing of refuse and scrap.

407—CLEANING AND SWEEPING.

All amounts paid for service in raking, sweeping or otherwise cleaning the department.

408—UNLOADING MISCELLANEOUS MATERIALS.

Wages paid men for unloading miscellaneous materials of short term supply excepting as otherwise provided for in this classification.

409—EXPENSES DUE TO ERRORS AND DEFECTS.

Expenses or losses due to errors of department employes whether mechanical or clerical, as for example; breakage, spoilage, misplacement or careless shop work of any kind.

410—SICKNESS AND ACCIDENT RELIEF.

Wages paid to employes absent on account of sickness or accident. Allowances must be approved by the Superintendent.

411—GENERAL LABOR.

Wages paid to miscellaneous general labor not provided for in this classification.

412—SHIPPING EXPENSE LABOR.

Wages paid shipping department helpers and laborers wherever located.

413—..

414—..

MAINTENANCE AND SUPPLIES.

421—BUILDINGS.
Labor and material used in repairing or partially renewing buildings or structures.

422—TUMBLERS.
Labor and material used in repairing or partially renewing all tumbling barrels or rolling mills.

423—GRINDERS.
Labor and material used in repairing or partially renewing all grinders. Does not include grind stones or emery wheels.

424—MACHINERY.
Labor and material used in repairing or partially renewing all transmission machinery within the department.

425—AIR TOOLS.
Labor and material used in repairing or partially renewing all air tools and connections used in the department.

426—CRANES.
Labor and material used in repairing or partially rénewing all cranes, chain hoists and mechanical conveyors used in the department.

427—ELECTRICAL APPARATUS.
Labor and material used in repairing or partially renewing all electrical apparatus.

428—SAND BLAST APPARATUS.
Labor and material used in repairing or partially renewing sand blast apparatus.

429—CUTTING AND WELDING EQUIPMENT.
Labor and material used in repairing or partially renewing all cutting and welding equipment.

430—SHOP FIXTURES.
Labor and material used in repairing or partially renewing all shop fixtures, such as benches, racks, bins, lockers, railings, etc.

431—PIPE AND POWER LINES.
Labor and material used in repairing or partially renewing all piping, plumbing and electric wiring inside of buildings, including drainage and sewer pipes, water, gas, air and oil pipes and their fittings; cables and wires for power and lighting circuits, including wiring devices.

432—OTHER EQUIPMENT.
Labor and material used in repairing or partially renewing all other equipment not pro-provided for in this classification.

433—SAND FOR SAND BLAST.
Cost of sand used in sand blasting during the month (i. e., invoice price plus transportation charges).

434—NONDURABLE TOOLS.
Cost of repairing and renewing all tools and equipment of a nondurable nature, excepting emery wheels, not classed as a miscellaneous shop supply. This account is intended to cover mainly those classes of portable tools which are short lived and comparatively inexpensive. All current expenditures for nondurable tools should be distributed to this account whether such expenditures represent initial cost of additions or replacement of the nondurable tool equipment.

435—ELECTRIC LAMPS.
Expense in connection with lamp globes, carbons and bulbs.

436—EMERY WHEELS.
Expense of emery wheels used in the finishing department. This account is used to exclude the expenses of emery wheels from Account 434, Nondurable Tools.

437—CARBIDE, HYDROGEN AND OXYGEN.
Cost of carbide, hydrogen and oxygen used during the month in cutting and welding processes.

438—WELDING MATERIAL.
Cost of all welding supplies such as metal sticks or wire, flux, etc.

439—SHIPPING EXPENSE MATERIALS.
Cost of all miscellaneous materials used in connection with shipping expense operations

440—INSPECTION EXPENSE.
All incidental and miscellaneous expenditures (excepting labor) in connection with inspection of the company's product.

441—OTHER MATERIALS AND EXPENSES.
All incidental and miscellaneous disbursements not otherwise provided for in this classification.

442—..

443..

ANNEALING COST. GROUP 7.

501—FOREMEN.
All amounts paid for services of foremen.

502—OVEN TENDERS.
Wages of men operating annealing ovens including firing.

503—PACKING LABOR.
Wages paid for packing castings in annealing boxes or pots, or loading annealing cars.

504—PACKING MATERIALS.
Cost of packing materials used in annealing pots or boxes.

505—EXPENSES DUE TO ERRORS AND DEFECTS.
Expenses or losses due to errors of department employes whether mechanical or clerical, as for example, breakage, spoilage, misplacement or careless shop work of any kind.

506—BOXES.
Cost of annealing boxes used during the month.

507—FUEL CONSUMED.
Cost of all fuel used in the annealing ovens.

508—MAINTENANCE OF OVENS.
Labor and material used in repairing or partially renewing all annealing ovens.

509—MAINTENANCE OF ELECTRICAL APPARATUS.
Labor and material used in repairing or partially renewing all electrical apparatus.

510—MAINTENANCE OF BUILDINGS.
Labor and material used in repairing or partially renewing buildings or structures.

511—MAINTENANCE OF MISCELLANEOUS EQUIPMENT.
Labor and material used in repairing or partially renewing all other equipment not provided for in this classification.

512—SHEET IRON USED IN MUFFLE FURNACES.
Cost of all sheet iron used in muffle furnaces.

513—MISCELLANEOUS SUPPLIES.
Cost of all miscellaneous supplies (other than enumerated above) consumed in the current operations of the annealing departments.

514..

515..

APPORTIONED EXPENSES. GROUP 8.

1—POWER, HEAT AND LIGHT. (See detail 8a.)
Includes total of Group (8a) Power, Heat and Light Expenses, which amount shall be distributed on the proportionate basis of—

(a) **Power:** On the estimated used horsepower of motors installed in each department, to the total horsepower used in all departments.

(b) **Heat:** On the ratio of the floor space of each department heated to the total floor space of all departments heated.

(c) **Light:** On the wattage of lamps installed in each department to the total wattage installed in all departments.

2—PATTERN EXPENSES. (See detail 8b.)

Includes total of Group 8b Pattern Expenses, which amount shall be distributed against The Molding and Coremaking departments on the established proportionate basis of the benefits derived by each.

3—GENERAL EXPENSES. (See detail 8c.)

Includes total of Group 8c General Expenses, which amount shall be distributed to the following accounts: (a) cost of melt; (b) molding burden; (c) coremaking burden; (d) finishing cost; and (e) annealing cost, on a percentage basis equivalent to total labor cost direct and indirect in the respective departments.

4—BONUS.

(a) **Attendance:** Based on percentage of earnings during six consecutive days' full time attendance. Bonus to be distributed against department in which it is earned.

(b) **Quantity:** Based on quantity production weekly or monthly. Bonus to be distributed against department in which it is earned.

5—DEPRECIATION.

Represents a monthly charge equivalent to the lessening value of investments as represented by building, machinery, electrical apparatus, furniture and other permanent equipment, the charge being based on a standard rate of percentage of the ledger values of the investment accounts which shall be chargeable against the expenses of the various departments according to the value of the departmental investment.

6—INSURANCE.

(a) **Fire Insurance.**

Includes the cost of fire insurance premiums. Charges to this expense shall be credited to such an account as "Unexpired Insurance" and be distributed monthly against the various departments on the basis of value involved.

(b) **Group Life Insurance.**

Includes the cost of group life insurance premiums distributed monthly against the various expense groups (i. e., Groups 1 to 8 inclusive) based on the number of employes in each department.

(c) **Liability Insurance.**

Includes cost of all premiums on employers' liability insurance and is to be distributed monthly on a proportionate percentage of the payroll of each department.

7—TAXES.

Includes all payments for taxes and assessments on real estate and personal property used for manufacturing purposes, excepting water taxes. The estimated cost of taxes is to be credited to an account such as "Taxes Accrued" and charged in monthly proportions against the various departments on the basis of the ratio of taxable values in each department to the total taxable values in all departments.

POWER, HEAT AND LIGHT EXPENSES. GROUP 8-a.

601—POWER PLANT AND SUB-STATION LABOR.

All amounts paid for services of engineer, firemen, electrician, or other supervision and labor in connection with the power plant or sub-station.

602—MAINTENANCE OF POWER PLANT EQUIPMENT.

Labor and material used in repairing or partially renewing all power plant equipment excepting stationary boiler.

603—MAINTENANCE OF SUB-STATION EQUIPMENT.

Labor and materials used in repairing or partially renewing all sub-station equipment such as transformers, switchboard, general power lines and all other miscellaneous electrical apparatus used in distributing or measuring electrical current.

604—OILS AND WASTE.

Cost of all lubricating oils, greases and waste.

605—**ELECTRIC LAMPS.**

Expenses in connection with lamp globes, carbons and bulbs.

606—**FUEL CONSUMED.**

Cost of coal or other fuel actually consumed based on periodical reports of consumption.

607—**MAINTENANCE OF POWER PLANT BUILDINGS.**

Labor and material used in repairing or partially renewing all power plant buildings and structures.

608—**MAINTENANCE OF BOILER AND EQUIPMENT.**

Labor and material used in repairing or partially renewing stationary steam boilers or other apparatus used in connection with the generation or distribution of steam, as injectors, draft system, pipes and fittings, water pumps, etc.

609—**CURRENT PURCHASED.**

Cost of all electric current purchased for either power or light.

610—**MISCELLANEOUS EXPENSES.**

Miscellaneous expenses not otherwise provided for in this classification.

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Note No. 1—If compressed air is used in quantity and is supplied from a central station, it is recommended that a separate group expense be used like the "Power, Light and Heat" and handled in same way.

In many plants, however, a compressor is in each department where used, which of course would simply throw it in the expense account of the department.

In larger plants, however, a separate account should be used in similar manner to Power, Light and Heat.

Note No. 2—In large plants it is recommended to split Group 8-a, Power, Light and Heat, separating into an expense account for "Electric" and another for "Steam" expense. The same principles will govern and can easily be followed out.

PATTERN SHOP EXPENSES. GROUP 8-b.

701—**FOREMAN.**

Wages for foreman for time spent in supervision. Does not include wages of working foreman which can be directly distributed against pattern orders, shop orders or other standing expense accounts.

702—**ALTERATIONS AND REPAIRS TO PATTERNS.**

Labor and material used in the alteration or repair of standard patterns owned by the company to suit the needs of the foundry. Does not include labor and material used in the alteration or repair of patterns which are customers' property; does not include labor and material used in making new patterns which are chargeable to customers or an investment account.

The total amount charged to this account shall be deducted from pattern shop expenses and transferred to Account 233, Patterns, together with a proportion of the residual pattern shop expenses after values in Accounts 702, 703, 704 and 705 have been deducted from charges to this expense group. The proportion shall be based on a percentage basis of the ratio of the value in Account 702 to the total of the values in Accounts 702, 703, 704, 705.

703—**ALTERATIONS AND REPAIRS TO CORE BOXES.**

Labor and material used in the alterations or repair of standard core boxes owned by the company to suit the needs of the foundry. Does not include labor and material used in the alteration or repair of core boxes which are customers' property; does not include labor and material used in making new core boxes which are chargeable to customers or an investment account.

The total amount charged to this account shall be deducted from pattern shop expenses and transferred to Account 331, Core Boxes, together with a proportion of the residual pattern shop expenses after values in Accounts 702, 703, 704 and 705 have been de-

ducted from charges to this expense group. The proportion shall be based on a percentage basis of the ratio of the value in Account 703 to the total of the values in Accounts 702, 703, 704, 705.

704—MAKING NEW OR REPLACING OLD WOOD FLASKS.

Labor and material used in making new, repairing or replacing old wood flasks or bottom boards.

The total amount charged to this account shall be deducted from pattern shop expenses and transferred to Account 235-1, wood flasks and bottom boards, together with a proportion of the residual pattern shop expenses after values in Accounts 702, 703, 704 and 705 have been deducted from charges to this expense group. The proportion shall be based on a percentage basis of the ratio of the value in Account 704 to the total values in Accounts 702, 703, 704, 705.

705—MAINTENANCE OF SNAP FLASKS.

Labor and material used in repairing or partially renewing snap flasks and making new or replacing old wood jackets.

The total amount charged to this account shall be deducted from pattern shop expenses and transferred to Account 235-2, snap flasks and jackets, together with a proportion of the residual pattern shop expenses after values in Accounts 702, 703, 704 and 705 have been deducted from charges to this expense group. The proportion shall be based on a percentage basis of the ratio of the value in Account 705 to the total values in Accounts 702, 703, 704, 705.

706—MAINTENANCE OF BUILDINGS.

Labor and material used in repairing or partially renewing buildings or structures.

707—MAINTENANCE OF MACHINERY.

Labor and material used in repairing or partially renewing all machinery in pattern shop.

708—MAINTENANCE OF SHOP FIXTURES.

Labor and material used in repairing or partially renewing all shop fixtures, such as benches, racks, bins, lockers, railings, etc.

709—MISCELLANEOUS LUMBER.

Cost of all lumber used for miscellaneous purposes, not provided for in this classification. All charges possible should be made against Accounts 702 to 705 inclusive.

710—NONDURABLE TOOLS.

Cost of repairing and renewing all tools and equipment of a nondurable nature. This amount is intended to cover mainly those classes of portable tools which are shortlived and comparatively inexpensive. All current expenditures for nondurable tools should be distributed to this account whether such expenditures represent initial cost of additions or replacement of the nondurable tool equipment.

711—MISCELLANEOUS SUPPLIES AND EXPENSES.

Miscellaneous disbursements not otherwise provided for in this classification.

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GENERAL EXPENSES. GROUP 8-c.

801—SALARIES—DEPARTMENT HEADS.

Salaries of managers, general superintendents and those having supervision over a regularly established general department. (Not a producing department.)

802—SALARIES—CLERICAL.

Salaries and wages of all office clerks not directly distributable to a departmental expense account.

803—YARD LABOR.

Wages paid men engaged in general yard labor not distributed to other accounts provided herein.

804—GENERAL LABOR.

Wages paid men engaged in unclassified work not distributed to other accounts in this classification.

805—GENERAL REPAIR MEN.

Wages only of employes in the maintenance department which are not distributable directly to specific accounts as provided for in this expense classification.

806—SICKNESS AND ACCIDENT RELIEF.

Wages paid to employes absent on account of sickness or accident, which are not chargeable to operating departments. Allowances must be approved by the Superintendent.

807—PRINTING AND STATIONERY.

Cost of all printed forms and stationery used during the month by plant departments.

808—OFFICE SUPPLIES.

Cost of all minor office supplies and conveniences used by plant offices.

809—TRAVELING EXPENSES.

All payments for transportation, hotel and other necessary expenses in connection with foundry requirements other than administrative and selling.

810—TELEPHONE AND TELEGRAPH.

Expense of all local and long distance public telephone service, the rental of interior service and a proportion of wages of the switchboard operator based on services performed. Includes expense of telegraphing. All the preceding applies to Plant Operations.

811—CAR DEMURRAGE.

All amounts paid as demurrage for detention of cars belonging to railroad companies.

812—GENERAL STORES EXPENSE.

Wages of storekeeper and assistants engaged in the receiving, storing and delivery of general stores. This account also includes office supplies and stationery used in connection with the above function.

813—WATCHMEN'S EXPENSE.

Wages paid watchmen and other miscellaneous expenditures in connection with watchmen's service.

814—BLACKSMITH SHOP EXPENSES.

All expenditures in connection with the blacksmith shop not distributable directly to some other account. Includes labor and material and all pro-rations applicable to the blacksmith shop.

815—REPAIR DEPARTMENT EXPENSES.

All expenditures in connection with the repair or maintenance department not distributable directly to some other account. Includes labor and material and all prorations applicable to the repair department.

816—TRUCKING OR TEAMING EXPENSES.

All expenditures in connection with garage and automobile service, stable and cartage service and all payments for all miscellaneous and unassignable hired cartage of material and supplies, both incoming and outgoing.

817—MAINTENANCE OF OFFICE BUILDING.

All labor and material used in repairing or partially renewing office building.

818—MAINTENANCE OF BUILDINGS AND EQUIPMENT. (GENERAL.)

All labor and material used in repairing or partially renewing buildings and equipment when such charges cannot be distributed against a particular department as provided for in this classification.

819—MAINTENANCE OF YARDS, FENCES AND GROUNDS.

All labor and material used in repairing or partially renewing all roadways, sidewalks, fences, regrading of yards, maintaining lawns and all tools and implements used exclusively in connection therewith.

820—MAINTENANCE OF TRACKS.

All labor and material used in repairing or partially renewing all railway tracks in yards and shops, including turntables and tracks on trestles.

821—REPAIRS ON RETURNED MATERIAL.

Wages paid for reclaiming processes on returned material to restore such material to salable condition if defect is not directly traceable to an operating department

822—MISCELLANEOUS EXPENSES.

Miscellaneous disbursements not otherwise provided for in this classification.

ADMINISTRATIVE EXPENSES. GROUP 9.

1001—EXECUTIVES' SALARIES.

Compensation of corporate and general executive officers. Executive officers engaged in sales work should be charged directly to Account No. 1101—Salaries, under Group 10, Selling Expenses.

1002—OFFICE SALARIES.

Salaries of all clerks, including stenographers, reporting directly to the executive officers.

1003—OFFICE SUPPLIES AND EXPENSES.

Cost of all stationery, printed forms, office supplies and miscellaneous expenditures made in connection with executive offices.

1004—TRAVELING EXPENSES.

Payments for transportation, hotel and other necessary expenses, including entertaining incurred by executive officers.

1005—ASSOCIATION DUES.

Membership fees in trade or manufacturing associations.

1006—CHARITIES.

Cost of all voluntary subscriptions to hospitals or other local charity organizations.

1007—MISCELLANEOUS EXPENSES.

Miscellaneous disbursements not otherwise provided for in this classification.

SELLING EXPENSES. GROUP 10.

1101—SALARIES.

Salaries of sales manager, sales department representatives and clerks.

1102—COMMISSIONS.

All amounts accrued as commissions to salesmen based on sales billed (or orders taken) during the month.

1103—TRAVELING EXPENSES.

All payments for transportation, hotel and other necessary expenses, including entertaining, incurred by sales department representatives.

1104—OFFICE SUPPLIES AND EXPENSES.

Cost of all stationery, printed forms, office supplies used, and miscellaneous expenditures made in connection with the sales department.

1105—ADVERTISING.

Cost of all catalogs, price lists, stock lists, and all other printed matter intended to be of sales assistance. Includes payment for advertisements descriptive of the company's business or product inserted in newspapers, magazines, trade publications, etc., also cuts, electros, etc., used in connection therewith. Includes cost of samples for use of salesmen.

1106—TELEPHONE AND TELEGRAPH.

Local and long distance public telephone service, the rental of interior service, and a proportion of the wages of the switchboard operator based on services performed. Includes expense of telegraphing.

1107—POSTAGE.

Self-explanatory.

1108—MISCELLANEOUS EXPENSES.

Miscellaneous disbursements not otherwise provided for in this classification.

SECTION IV

PRODUCTION ROUTINE

All castings made should be authorized by a casting production order which should be in sufficient copies to notify the various departments interested of the exact requirements involved and to prevent over-fulfillment of requirements. The order should show clearly the order number or class number chargeable, in order that the application of cost may be dependable. A work-in-process record by pattern numbers should be maintained showing the order number and number of castings ordered and completed, as well as dates of the transactions. Dependable reports should be made showing the number of castings made daily, good and defective, and the corresponding weights by order or class number and pattern numbers.

SECTION V

COST COMPILATION

The compilation of costs consists of two main divisions:

First: The compiling of the monthly statements of the various operating expense and burden accounts, which accounts give us a complete analysis of all indirect costs, and a monthly and average to date check on our predetermined rates, and

Second: The compiling of casting or class costs based on weights and direct labor cost of product turned out, using predetermined rates on all except the direct labor.

In compiling the costs of the first division, we combine with the actual compilation the operation of securing the figures for the necessary journal entries to make the proper transfers—we therefore will trace through the detail work necessary to accomplish all ends:

First Division—Compiling Expense and Burden Accounts

All time tickets, requisitions, and expense ledger charge slips are filed under their proper order numbers.

For the work of compiling the statements, there should be prepared ahead a skeleton statement for each account for a working paper with headings as follows: (Refer to statements shown later in this section.)

ORDER NO.	TIME TICKETS	REQUISITIONS	EXPENSE LEDGER CHARGE SLIPS	MISCELLANEOUS	TOTAL FOR MONTH

The order number indicates the expense code order number. All other headings are clear except possibly "Miscellaneous." This is suggested in case some foundry uses a transfer charge slip from some other department of the same company.

With these skeleton working statements ready, start in with the operating account, and

First:—Add time tickets under each order number setting total opposite proper order number and under "Time Tickets."

Find total for each section of expense or burden account as per sample statements. Find total for each account. Find total for all accounts, including power, light and heat, pattern, general expense, etc.

This total should agree with the total indirect labor shown by the payroll distributions.

The figures here found showing total for each department become the debits to same in the labor distribution journal entry, and with the addition of the amounts for each productive depart-

ment of direct labor shown by the pay roll distribution, make up the complete journal entry for labor distribution for the month.

Second:—Add requisitions same way as time slips and enter.

The total for each account gives the figure for the debits side of the journal entry of distribution of material, the credit side being the figures accumulated before the requisitions were filed, where the amounts to be credited to each stock material account was found. This also gives a check on the accuracy of the work performed at all stages, as these figures must agree to make a balanced entry.

Third:—Add and enter the expense ledger charge slips exactly the same way. This will give the debits to the various expense and burden accounts, and the total *credit* to expense ledger account.

Note that this credit must equal the total of the debits as comes from the purchase register.

Journal entry No. 2 combines the second and third items here shown into one entry. They can be made separately if desired.

Fourth:—If some purely local method is installed to control charges from other departments through some "Deferred Charge" method use the column headed "Miscellaneous." Proceed as in other cases.

Fifth:—Without going into the detail of each, prepare monthly journal entries covering distribution of:

Liability insurance
Depreciation
Taxes
Fire insurance
And any other desired items.
(See journal entries for methods to use.)

Sixth:—Now close the accounts.

Power, light and heat
Pattern expense
General expense

distributing them as per directions elsewhere, making up proper journal entries of same.

Seventh:—We now have all items in our operating expense and burden accounts, and same can be completely footed.

Eighth:—Next get the necessary data of total metal poured; direct molding labor; direct coremaking labor; and total good castings.

Ninth:—Prepare journal entry and make entries on statements as follows: (Debit is to Work in Process.)

Melting Cost is credited with pounds of metal poured times the predetermined rate per pound.

Molding Burden-Direct Labor with direct labor times predetermined rate.

Molding Burden-Machine Hour with hours of machine work times predetermined rate.

Coremaking Burden-Direct Labor with direct labor times predetermined rate.

Coremaking Burden-Machine Hour with hours of machine work, times predetermined rate.

Finishing Cost with combined molding and core direct labor times predetermined rate.

Annealing Cost with weight good castings times predetermined rate.

Important Note.—There are two ledger accounts for each operating expense and burden account. One, named as those above are for debits or adjustments of same only, and the other is for the credits through transfers to work in process each month. The object of this is to accumulate the burden amounts to date each month, also the burden credits—for use in the comparative statements. The difference between each pair of accounts is the over or under absorbed expense, carried to the profit and loss statement monthly, but not journalized except at yearly closing of books.

Tenth:—With all data now known, fill in and compute the comparative statements of each expense and burden account.

Second Division—Compiling Casting and Class Costs

All time tickets representing the direct labor are filed under the order or class number. Weight records are known of weights of the castings to be figured as well as the sprue weights of same, and which castings weights are good—and bad.

The following form will then be followed either for individual castings of classes:

Casting Cost Sheet

Total metal poured............—— #@ —— per lb.		——	
Less bad castings.............—— #@ —— per lb. ——			
Sprue ....—— #@ —— per lb. ——		——	
Net metal cost...............			——
Molding direct labor...	——		
Molding burden @ ——% of direct labor..................	——		
Molding burden @ ——hrs. machine @ —— per hr..........	——		
Net molding department cost............................			——
Coremaking direct labor....................................	——		
Coremaking burden @ ——% of direct labor...............	——		
Coremaking burden @ ——hrs. machine @ —— per hr......	——		
Net coremaking department cost.........................			——
Finishing cost @ ——% of combined molding & core direct labor	——		
Annealing cost @ ——% per lb. of good castings...........	——		
Total plant cost			——

If molding sand and flask cost is used separately, add to the foregoing.

Molding sand cost —— # poured @ —— per lb................ ——

Flask cost —— good castings @ —— per lb................ ——

The credit of bad castings and sprue is usually given at some regular arbitrary price per pound, but of course closely approximating current value of scrap.

Class Costs—Individual Costs

Different foundries use different methods depending on the nature of their work.

Class Costs

If class costs are used, a subsidiary record should be used for pricing sales for the month used as follows, and for the reasons given.

It is necessary to close up all classes monthly. Of course *some* castings are not complete—are in process. So, therefore, no one month's figures mean much as against the average of a number of months.

Also, some castings at one month's cost are shipped during the *next* month, when the *month's* class cost is different.

So, therefore, a running record for each class should be kept as follows:

	Pounds	Per Lb.	Amount
Balance	0000	000	00000
Produced this month	00000	000	000000
Total	00000	000	000000
Shipped	00000	000	000000
Balance	0000	000	00000

By this the unshipped tonnage—at its value is carried over. The production *at the cost for the month* is added, which gives us a total and thereby an *averaged* cost. This cost per pound we use in pricing the shipments for the month, leaving a balance forward unshipped to repeat next month. This will insure equitable pricing of sales, and keep the inventories at proper values.

Individual Costs

In the case of individual casting costs, the troubles experienced in class cost are not apparent, as each casting order is on its own basis. It is simply a matter of costing the shipments as made by the use of weights and direct labor with predetermined costs of expenses and burdens.

Closing Costs of Orders or Classes

We now must prepare our journal entries and use the cost compiled in the second section.

First:—An accumulation of all bad castings and sprue must be made for the month. This will be the total of this deduction in the cost sheets. This gives us the journal entry to credit work in process and debit scrap. This also comes from inspector's reports.

Second:—The cost of completed castings will be transferred from work in process to finished castings—if put into stock or to cost of castings sales if castings are not stocked. This is journal entry No. 12 or 13.

Third:—If individual castings costs are figured, this cost should be entered on the invoices and from there recapped, in order to be sure that each sale is priced.

Fourth:—If class costs are used, a recap of shipments under each class will be made, and then priced as per method under "class costs—individual costs." In both this and the preceding entry, remember the journal entry.

Monthly Cost, Profit and Loss and Balance Sheets

Immediately following are forms of cost sheets for all expense and burden accounts, profit and loss and balance sheet.

If the form of statements is carried out, and all previous directions, no trouble will be experienced.

Each operating statement shows place for credit of predetermined amounts, and shows the balance under or over absorbed. These balances are carried into the profit and loss credits red, and debits black.

Then insert the administrative and selling costs as figured on the working sheets, as well as sales, financial items, etc., and the profit or loss is arrived at.

From the trial balance fill in all the items on the balance sheet, and this should show same results as the profit and loss sheet.

* * * * * *

A method of accounts which is not the means of pointing the way to reforms is a failure. An industrial plant which fails to have such a method is far behind the times. Nor does an elaborate method accomplish more than a simple method, if the management *fails to use the figures set forth.*

Costs may *cost,* or may become an *investment.* It's up

to the *use* of the figures whether the cost system in a plant is an *expense* or an *investment.* You can make it an investment if you will—and a very profitable one by getting everyone interested in every detail—in every item of every expense and burden account.

Bonuses or prizes may be worked out—and almost any method at all when you have the figures and use them.

Besides that—you *know* your costs.

Special Note—Financial Expense

Theoretically, all interest and discounts are straight profit and loss items.

Interest on loans in banks are but payments on account of insufficient capital, and therefore are in place of what otherwise would be stock dividends.

Cash discounts given are really the same as interest paid, and are *not* selling expenses.

However, many companies desire to include interest expenses as a part of the administrative expense in their costs, on the theory that the interest has to be earned and the best way to be more assured is to thus include it in the cost.

In the statement of profit and loss shown herewith, the financial section stands alone and may or may not be combined with the administrative expense, according to the desires of the officers of the company.

MELTING COST
CONVERSION
MONTH OF

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
LABOR			
101. Foremen and assistants			
102. Timekeepers and other clerks			
103. Unloading melting materials			
104. Cupola or furnace labor			
105. Elevator and cranemen			
106. Breaking scrap			
107. Handling slag			
108. Testing materials and product			
109. Melting materials stores labor			
110. Sickness and accident relief			
111. General labor			
TOTAL			
Total Forward			

MELTING COST
CONVERSION
MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
FORWARD			
MAINTENANCE OF PROPERTY			
121. Buildings			
122. Cupolas and furnaces			
123. Converters			
124. Elevators, cranes and conveyors			
125. Electrical apparatus			
126. Pipe and power lines			
127. Platform and stairways			
TOTAL			
SUPPLIES			
141. Aluminum			
142. Brick			
143. Clay			
144. Coke			
145. Electrodes			
146. Fuel oil			
147. Lime			
148. Limestone			
149. Lining materials			
150. Sand			
151. Miscellaneous supplies			
152. Laboratory expenses			
TOTAL			
APPORTIONED CHARGES			
Bonus			
Depreciation			
General expenses			
Insurance			
Power, heat and light			
Taxes			
TOTAL			
TOTAL CONVERSION COST			
METAL COST			
METALS			
Pig iron			
Purchased scrap			
Iron scrap			
Ferro manganese			
Ferro silicon			
Iron ore			
TOTAL METAL COST			
TOTAL MELTING COST			
To WORK-IN-PROCESS account.			
Total poured			
lbs. @ ....per lb.			
Balance to PROFIT AND LOSS ACCOUNT			

MOLDING BURDEN—DIRECT LABOR

MONTH OF.... ....

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
INDIRECT LABOR			
201. Foreman and assistants			
202. Timekeepers and other clerks			
203. Cutting sand and preparing floors			
204. Closing and clamping molds			
205. Drying molds			
206. Runner cups			
207. Broken molds			
208. Carrying patterns and flasks			
209. Pouring			
210. Shaking out			
211. Taking out refuse and scrap			
212. Cleaning and sweeping			
213. Crane operator			
214. Idle time			
215. Sickness and accident relief			
216. Pattern storage labor			
217. Expenses due to errors and defects			
218. General labor			
TOTAL			
MAINTENANCE AND SUPPLIES			
221. Buildings			
222. Molding machines			
223. Jarring machines			
224. Air hoists			
225. Cranes			
226. Electrical apparatus			
227. Shop fixtures			
228. Pipe and power lines			
229. Small tools			
230. Gaggers, chills, chaplets, and bolts			
231. Nails			
232. Lamp bulbs			
233. Patterns			
234. Molding sand			
235. Flasks			
236. Non-durable tools			
237. Metal arbors and cores			
238. Miscellaneous supplies and expenses			
TOTAL			
APPORTIONED CHARGES			
Bonus			
Depreciation			
General expense			
Insurance			
Pattern expenses			
Power, heat and light			
Taxes			
TOTAL			
TOTAL MOLDING BURDEN			
To WORK-IN-PROCESS account			
@ % of productive labor			
Balance to PROFIT AND LOSS account			

MOLDING BURDEN—MACHINE HOUR

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
DIRECT CHARGES			
251. Maintenance of molding machines..........			
252. Maintenance of jarring machines...........			
TOTAL			
APPORTIONED CHARGES			
Depreciation			
Power, light and heat.........................			
TOTAL			
TOTAL MOLDING BURDEN—MACHINE HOUR			
To WORK-IN-PROCESS account hrs. @ per hour...........			
Balance to PROFIT AND LOSS account............			

IF USED SEPARATELY

MOLDING SAND COST

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
234–1 Molding sand			
234–2 Unloading molding sand....................			
234–3 Mixing molding sand......................			
234–4 Maintenance of mixers.....................			
234–5 Miscellaneous supplies			
234–6 Miscellaneous expenses			
TOTAL			
To WORK-IN-PROCESS account lbs. metal poured @ per pound.......			
Balance to PROFIT AND LOSS...................			

FLASK COST

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
235–1 Wood flasks and bottom boards.............			
235–2 Snap flasks and jackets....................			
235–3 Metal flasks			
235–4 Flask plates			
TOTAL			
To WORK-IN-PROCESS account lbs. good castings @ per pound......			
Balance to PROFIT AND LOSS...................			

COREMAKING BURDEN—DIRECT LABOR

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
LABOR			
301. Foremen and assistants			
302. Timekeepers and other clerks			
303. Inspecting cores			
304. Unloading core sand			
305. Wheeling and mixing core sand			
306. Loading and tending ovens			
307. Handling cores			
308. Repairing cores			
309. Crane operator			
310. Storing cores			
311. Sickness and accident relief			
312. Exp. due to errors and defects			
313. General labor			
314.			
TOTAL			
MAINTENANCE AND SUPPLIES			
321. Buildings			
322. Coremaking machines			
323. Sandmixing machines			
324. Electrical apparatus			
325. Core ovens			
326. Shop fixtures			
327. Pipe and power lines			
328. Cranes			
329. Plates			
330. Small tools			
331. Core boxes			
332. Fuel consumed			
333. Core sand			
334. Clay			
335. Core compound and oil			
336. Flour			
337. Silica wash			
338. Rods, wires, nails			
339. Misc. supplies and expenses			
TOTAL			
APPORTIONED CHARGES			
Bonus			
Depreciation			
General expenses			
Insurance			
Pattern expenses			
Power, heat and light			
Taxes			
TOTAL			
TOTAL COREMAKING BURDEN			
To WORK-IN-PROCESS account @ % of Productive labor			
Balance to PROFIT AND LOSS account			

COREMAKING BURDEN—MACHINE HOUR

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
DIRECT CHARGES			
351. Maintenance of coremaking machines........			
APPORTIONED CHARGES			
Depreciation			
Power, light and heat..........................			
TOTAL			
TOTAL BURDEN MACHINE HOUR......			
To WORK-IN-PROCESS account hrs.			
@ per hour..........			
Balance to PROFIT AND LOSS..................			

FINISHING COST

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
LABOR			
401. Foremen and assistants....................			
402. Timekeepers and other clerks..............			
403. Inspectors			
404. Crane operator			
405. Handling good product....................			
406. Taking out refuse and scrap...............			
407. Cleaning and sweeping....................			
408. Unloading miscellaneous materials...........			
409. Expense due to errors and defects..........			
410. Sickness and accident relief..............			
411. General labor			
412. Shipping expense labor....................			
TOTAL			
MAINTENANCE AND SUPPLIES			
421. Buildings			
422. Tumblers			
423. Grinders			
424. Machinery			
425. Air tools			
426. Cranes			
427. Electrical apparatus			
428. Sand blast apparatus....................			
429. Cutting and welding equipment............			
430. Shop fixtures			
431. Pipe and power lines....................			
432. Other equipment			
433. Sand for sand blast....................			
434. Non-durable tools			
435. Electric lamps			
436. Emery wheels			
437. Carbide, hydrogen and oxygen..............			
438. Welding material			
439. Shipping expense materials................			
440. Inspection			
441. Other materials and expenses..............			
TOTAL			
Total Forward			

FINISHING COST

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
FORWARD			
APPORTIONED CHARGES			
Bonus			
Depreciation			
General expense			
Insurance			
Power, heat and light.........................			
Taxes			
TOTAL			
DIRECT OPERATIONS			
Caulking			
Chipping			
Cleaning			
Cutting			
Grinding			
Sand blasting			
Welding			
Etc.			
TOTAL			
TOTAL FINISHING COST..............			
To WORK-IN-PROCESS account @ % of total molding and core productive labor			
Balance to PROFIT AND LOSS account............			

ANNEALING COST

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
501. Foremen			
502. Oven tenders			
503. Packing labor			
504. Packing materials			
505. Expenses due to errors and defects			
506. Boxes			
507. Fuel consumed			
508. Maintenance of ovens			
509. Maintenance of electrical apparatus			
510. Maintenance of buildings			
511. Maintenance of miscellaneous equipment			
512. Sheet iron used in muffle furnace			
513. Miscellaneous supplies			
TOTAL			
APPORTIONED CHARGES			
Bonus			
Depreciation			
General expenses			
Insurance			
Power, heat and light			
Taxes			
TOTAL			
TOTAL ANNEALING COST			
To WORK-IN-PROCESS account			
Basis of lbs. good castings @ a lb.			
Balance to PROFIT AND LOSS account			

POWER, HEAT AND LIGHT EXPENSES

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
601. Power plant and substation labor			
602. Maintenance of power plant equipment			
603. Maintenance of substation equipment			
604. Oils and waste			
605. Electric lamps			
606. Fuel consumed			
607. Maintenance of power plant buildings			
608. Maintenance of boiler and equipment			
609. Current purchased			
610. Miscellaneous expense			
TOTAL			
APPORTIONED CHARGES			
Bonus			
Depreciation			
Insurance			
Taxes			
TOTAL			
TOTAL POWER, HEAT AND LIGHT EXPENSES			

POWER, HEAT AND LIGHT EXPENSES—Continued

		LAST MONTH	THIS MONTH	THIS YEAR TO DATE
Transferred to following accounts:				
Melting cost	%			
Molding Burden—Direct Labor	%			
Molding Burden—Machine Hour	%			
Coremaking Burden—Direct Labor	%			
Coremaking Burden—Machine Hour	%			
Finishing cost	%			
Annealing cost	%			
Pattern shop expense	%			
General expenses	%			
	100%			

PATTERN SHOP EXPENSES

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
701. Foremen			
702. Alterations and repairs to patterns			
703. Alterations and repairs to core boxes			
704. Making new or replacing old wood flasks			
705. Maintenance of snap flasks			
706. Maintenance of buildings			
707. Maintenance of machinery			
708. Maintenance of shop fixtures			
709. Miscellaneous lumber			
710. Nondurable tools			
711. Miscellaneous supplies and expenses			
TOTAL			
TOTAL PATTERN SHOP EXPENSES			
Transferred to following accounts:			
Value in Account 702 to Account 233			
Value in Account 703 to Account 331			
Value in Account 704 to Account 235-1			
Value in Account 705 to Account 235-2			
Residue of $.................... to			
Molding burden %			
Coremaking burden %			
100%			

GENERAL EXPENSES

MONTH OF....................

	LAST MONTH	THIS MONTH	THIS YEAR TO DATE
801. Salaries—Department Heads			
802. Salaries—Clerical			
803. Yard labor			
804. General labor			
805. General repair men			
806. Sickness and accident relief			
807. Printing and stationery			
808. Office supplies			
809. Traveling expenses			
810. Telephone and telegraph			
811. Car demurrage			
812. General stores expenses			
813. Watchmen's expense			
814. Blacksmith shop expense			
815. Repair department expense			
816. Trucking or teaming expense			
817. Maintenance of office building			
818. Maintenance of buildings and equipment (general)			
819. Maintenance of yards, fences and grounds			
820. Maintenance of tracks			
821. Repairs on returned material			
822. Miscellaneous expenses			
TOTAL			
APPORTIONED CHARGES			
Bonus			
Depreciation			
Insurance			
Taxes			
General charge (If a part of a company of many departments.)			
TOTAL			
TOTAL GENERAL EXPENSES			
Transferred to following accounts:			
Melting cost .... %			
Molding burden .... %			
Coremaking burden .... %			
Finishing cost .... %			
Annealing cost .... %			
100%			

MONTHLY COMPARISONS

The following monthly comparative statistical reports should be compiled and are derived from the monthly reports previously mentioned:

Comparative Cost of Melt

1919	METAL POURED		COST OF MELT		COST PER POUND	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Cost of Conversion

1919	METAL POURED		CONVERSION COST		COST PER POUND	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Per Cent Molding Burden—Direct Labor To Direct Labor

1919	DIRECT LABOR		MOLDING BURDEN		DEPARTMENT %	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Cost Molding Burden—Machine Hour To Actual Machine Hours

1919	ACTUAL MCH. HOURS		MACHINE COST		COST PER HOUR	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Molding Sand Cost

1919	METAL POURED		SAND COST		COST PER POUND	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Flask Cost

1919	GOOD CASTINGS		FLASK COST		COST PER POUND	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Per Cent Coremaking Burden—Direct Labor To Direct Labor

1919	DIRECT LABOR		COREMAKING BURDEN		DEPARTMENT %	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Cost Coremaking Burden—Machine Hour To Actual Machine Hours

1919	ACTUAL MCH. HOURS		MACHINE COST		COST PER HOUR	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Per Cent Finishing Cost to Molding and Core Direct Labor

1919	MLDG. & CORE PROD. LABOR		FINISHING COST		DEPARTMENT %	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Comparative Annealing Cost

1919	GOOD CASTINGS		ANNEAL COST		COST PER POUND	
MONTH	MONTH	TOTAL	MONTH	TOTAL	MONTH	AVERAGE
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

AMERICAN FOUNDRYMEN'S ASSOCIATION

PROFIT AND LOSS ACCOUNT

Month of 1919
(Credits Red—Debits Black)

	Total to Date	Current Month	Last Month	Inc. in Red Dec. in Black
SALES—CASTINGS				
Cost of castings sales.................				
Total				
MISCELLANEOUS SALES				
Cost of miscellaneous sales............				
Total				
TOTAL				
Less freight out on sales..............				
GROSS PROFIT				
PLANT BALANCES				
Melting cost				
Molding burden—direct labor.........				
Molding burden—machine hour.......				
Coremaking burden—direct labor......				
Coremaking burden—machine hour.....				
Finishing cost				
Annealing cost				
Molding sand cost.................				
Flask cost				
Total Plant Balances............				
NET MFG. PROFIT FORWARD......				
ADMINISTRATIVE EXPENSE				
Executive salaries				
Office salaries				
Office supplies and expenses.........				
Traveling expenses				
Association dues				
Charities				
Miscellaneous expenses				
Total administrative				
SELLING EXPENSE				
Selling salaries				
Commissions				
Traveling expenses				
Office supplies and expenses.........				
Advertising				
Telephone and telegraph.............				
Postage				
Miscellaneous expenses				
Total selling expenses...........				
FINANCIAL				
Interest paid				
Interest received				
Cash discount allowed customers......				
Cash discount taken on purchases.....				
Total financial..................				
TOTAL ADM. SELLING & FIN. FWD.				

AMERICAN FOUNDRYMEN'S ASSOCIATION

PROFIT AND LOSS ACCOUNT

Month of 1919

(Credits Red—Debits Black)

	Total to Date	Current Month	Last Month	Inc. in Red Dec. in Black
NET MANUFACTURING PROFIT FORWARD				
TOTAL ADMIN. SELLING & FIN. FWD.				
MISCELLANEOUS				
Insert here any miscel. a/cs such as				
Net real estate P. or L............				
(If any owned or rented)				
Loss on bad accounts...............				
Adjustment a/c				
(If any adjustments are necessary for any purpose)				
Total Miscellaneous				
TOTAL ADMIN., SELLING, FINANCIAL AND MISCELLANEOUS......				
NET PROFIT OR LOSS FOR MONTH				

AMERICAN FOUNDRYMEN'S ASSOCIATION

COMPARATIVE BALANCE SHEET

Month 31, 1919

	Current Month	Last Month of Last Year	Increase	Decrease
ASSETS				
Cash on hand and in banks............				
Bills receivable				
Accounts receivable				
Investments..............................				
Total Current Assets............				
Raw materials and in process..........				
Machinery and equipment..............				
Real estate and buildings..............				
Total Fixed Assets.............				
Prepaid insurance				
Prepaid taxes				
Prepaid interest				
Total Deferred Assets............				
Patents				
Goodwill				
Total Intangible Assets..........				
TOTAL ASSETS				
LIABILITIES				
Bills payable				
Accounts payable				
Accrued items				
Total Current Liabilities........				
Bonds payable				
Mortgages payable				
Total Fixed Liabilities..........				
Reserves				
Capital stock preferred...............				
Capital stock common.................				
Total Capital Liabilities.........				
Surplus				
Less inc. and ex. prof. tax for..........				
Dividends preferred				
Dividends common				
Total Surplus Deductions.........				
Add Profits to (Previous Mo.)...				
Profit for (Current Mo.)........				
Total Surplus Additions..........				
Net Surplus....................				
TOTAL LIABILITIES				

Use of Burden and Expense Statements

The burden and expense statements contain almost unlimited opportunities for cost cutting, as well as giving the figures for the adjusting of standard rates of burden for each operating department.

The indirect expense is really the greater and more elusive part of the cost of product. This is naturally so, as the direct labor, being charged to the various pattern or order numbers is in much more concrete and watchable form, and is of course the center of all piece work, bonus, or any other kind of stimulus producing effort.

But the overhead—the *burden*, for such it is in grim fact, is not only the greatest feature, but is the most neglected feature in the great majority of plants. Why?

The most common reason for neglect in most plants is on account of lack of knowledge of how to handle burden in a manner to show it up in usable form.

It has been the aim of this bulletin to make this perfectly clear; to supply definite directions which will permit anyone to go ahead. If the accounts do not quite fit, anyone can follow the principle and make up accounts as they desire.

So, the *twofold* feature of this bulletin should be carefully studied.

First:—It will give costs.

Second:—It will give costs that can be used for practical and cost cutting purposes.

The monthly comparisons give the unit costs, and percentages for each month and the average to date for the year. Monthly figures will, of course, vary; but the average to date is the figure to watch. If it gets off very far from the standard, then the standard will have to be changed. But don't worry for two or three months until you see how it is really running.

SECTION VI

JOURNAL ENTRIES

The following sequence of journalizing should be followed in order to distribute the various details into the cost of production and reflect the condition properly on the general ledger.

1. Payroll.
2. Materials and supplies.
3. Liability insurance.
4. Depreciation.
5. Taxes.
6. Fire insurance.
7. Power, heat and light.
8. Pattern shop expenses.
9. General expenses.
10. Departmental expenses.
11. Reversing foundry scrap.
12. Finished castings.
13. Shipments.

The following pages illustrate the details of the journal entries required.

1. PAYROLL:

Debit—

Work in process (direct labor)
Cost of melt (conversion labor).
Molding burden—direct labor.
Molding burden—machine hour.
Molding sand cost.
Flask cost.
Coremaking burden—direct labor.
Coremaking burden—machine hour.
Finishing cost.
Annealing cost.
Pattern shop expenses.
Power, heat and light expenses.
General expenses.

Credit—

Accrued payroll.

Purpose—

To distribute labor charges for current month.

Source—

Direct labor charges are taken from the molding and coremaking pay roll sheets and should equal the total of all direct labor daily time tickets filed under production order or class numbers for the same period.

Indirect labor charges to cost and burden accounts are obtained from the compilation of indirect labor daily time tickets filed under the various expense account numbers as described in Section III. The values thus accumulated by summarizing the labor tickets must agree with the total of the pay roll for the same period.

2. MATERIALS AND SUPPLIES:

Debit—

Cost of melt (Melting and conversion materials).
Molding burden—direct labor.
Molding burden—machine hour.
Molding sand cost.
Flask cost.
Coremaking burden—direct labor.
Coremaking burden—machine hour.
Finishing Cost.
Annealing Cost.
Pattern shop expenses.
Power, heat and light expenses.
General expenses.

Credit—

Melting Stock—metals.
1. Pig iron.
2. Purchased scrap.
3. Foundry scrap.
4. Ferromanganese.
5. Ferrosilicon.

General stores.
Any other controlling material accounts.
Expense ledger.

Purpose—

To distribute material requisitions and expense ledger charges for current month.

Source—

These charges are derived from a monthly summary of cupola or furnace reports, material requisitions and expense ledger charge slips representing materials consumed or purchases made during the current month distributed to the cost and burden accounts.

3. LIABILITY INSURANCE:

Debit—

Cost of melt.
Molding burden—direct labor.
Molding burden—machine hour.
Coremaking burden—direct labor.
Coremaking burden—machine hour.
Finishing Cost.
Annealing Cost.
Pattern shop expenses.
Power, heat and light expenses.
General expenses.

Credit—

Unexpired insurance.

Purpose—

To distribute pro-rata amount of liability insurance premiums to current month.

Source—

This distribution is based on an estimated monthly amount sufficient to absorb the yearly total of liability insurance premiums.

The pro-ration is based on the actual rate of the wages paid in each of the above accounts.

4. DEPRECIATION:

Debit—

Cost of melt.
Molding burden—direct labor.
Molding burden—machine hour.
Coremaking burden—direct labor.
Coremaking burden—machine hour.
Finishing Cost.
Annealing Cost.
Pattern shop expenses.
Power, heat and light expenses.
General expenses.

Credit—

Reserve for plant depreciation (As many Reserve Accounts as desired).

Purpose—

To distribute pro-rata amount of annual depreciation charge to current month.

Source—

One-twelfth of the annual depreciation charge distributed to the various departments, based on the investment in each department.

5. TAXES:

Debit—

Cost of melt.
Molding burden.
Coremaking burden.
Finishing Cost.
Annealing Cost.
Pattern shop expenses.
Power, heat and light expenses.
General expenses.
(In small plants this may all go to General Expense.)

Credit—

Accrued taxes.

Purpose—

To distribute pro-rata amount of estimated accrued taxes to current month.

Source—

One-twelfth of the estimated amount of yearly taxes distributed to the various departments based on the taxable property in each department.

6. FIRE INSURANCE:

Debit—

General expense.

Credit—

Unexpired insurance.

Purpose—

To distribute pro-rata amount of fire insurance premiums to current month.

Source—

One-twelfth of the annual amount of fire insurance premiums.

7. POWER, HEAT AND LIGHT:

Debit—

Cost of melt.
Molding burden—direct labor.
Molding burden—machine hour.
Coremaking burden—direct labor.
Coremaking burden—machine hour.
Finishing Cost.
Annealing Cost.
Pattern shop expenses.
General expenses.

Credit—

Power, heat and light expenses.

Purpose—

To distribute power, heat and light expense of current month.

Source—

The total of expenses summarized under group 8a, power, heat and light expenses, as described in Section 5.

8. PATTERN SHOP EXPENSES:

Debit—

Molding burden.
Coremaking burden.

Credit—

Pattern shop expenses.

Purpose—

To distribute pattern shop expenses of current month.

Source—

The total of expenses summarized under Group 8*b*, pattern shop expenses, as described in Section 5. The basis of distribution is defined in Section 3, expense routine, under Group 8*b*, Titles and definitions of accounts, pattern shop expenses.

9. GENERAL EXPENSES:

Debit—

Cost of melt.
Molding burden.
Coremaking burden.
Finishing Cost.
Annealing Cost.

Credit—

General expenses.

Purpose—

To distribute general expenses of current month.

Source—

The total of expenses summarized under Group 8*c*, general expenses, as described in Section 5. The basis of distribution is the total monthly labor cost in each of the above departments

10. DEPARTMENTAL EXPENSES:

Debit—

Work in process.

Credit—

Cost of melt (credit account).
Molding burden—direct labor (credit account).
Molding burden—machine hour (credit account).
Molding and sand cost (credit account).
Flask cost (credit account).

Coremaking burden—direct labor (credit account).
Coremaking burden—machine hour (credit account).
Finishing cost (credit account).
Annealing cost (credit account).

Purpose—

To transfer departmental burden and costs at their standard rate for current month to work in process.

Note:—Each account will have a net debit or credit balance which should be shown each month on the profit and loss statement. Actual closing of these departmental burden and cost accounts will not be made until the end of the year when they will be closed into profit and loss. Throughout the year the debit and credit postings to these departmental burden and cost accounts shall be accumulative totals for trial balance and checking purposes.

Source—

The total of all charges accumulated from all sources as shown in Section V. Cost compilation.

11. FOUNDRY SCRAP:

Debit—

Foundry scrap.

Credit—

Work in Process.

Purpose—

To reverse scrap value of bad castings and sprues accumulated during current month.

Source—

The total scrap value of bad castings and sprues as represented by monthly summary of inspectors' rejection reports showing weights of bad castings and sprues by classes or order numbers.

12. FINISHED CASTINGS:

Debit—

Finished castings (if account is used).

Credit—

Work in process.

Purpose—

To transfer from work in process to finished castings account value of finished product delivered to finished castings stores.

Source—

Summary of delivery tickets or scale reports representing delivery of finished castings to stock.

13. SHIPMENTS:

Debit—

Cost of castings sales.

Credit—

Work in process, or
Finished castings (if account is used).

Purpose—

To cover cost of castings shipped during current month.

Source—

Summary cost value applied on memoranda of shipment or shipments made during the current month.

SECTION VII

PLANT INVESTMENT CLASSIFICATION

As far as practicable the following plant investment accounts should be carried in the general ledger, the opening entries being based on the first cost or replacement value of the investment in each class. If such value is not determinable, an appraisal of the physical property should be made. The classification is intended to provide more than an analysis of the plant investment but to afford (1) a means of classification for depreciation group rates and (2) a basis for classification of maintenance charges and (3) a means of establishing reserves corresponding to each plant investment account.

1. Land.
2. Buildings and structures.
3. Cupolas, ovens and furnaces.
4. Piping and wiring.
5. Machinery and tools—cataloged.
6. Machinery and tools—miscellaneous.
7. Electrical equipment—cataloged.
8. Electrical equipment—miscellaneous.
9. Shafting, pulleys, hangers and belting.
10. Special machinery, jigs, fixtures, punches and dies.
11. Shop fixtures and equipment—miscellaneous.
12. Railway tracks and overhead equipment.
13. Rolling stock.
14. Trucks, teams and other conveyances.
15. Patterns.
16. Metal flasks.
17. Office furniture and appliances.
18. Power plant equipment.

These accounts should be consolidated for presentation on the balance sheet and shown as one amount against plant investment. Corresponding reserves should also be consolidated on the balance sheet and shown as general reserve for plant depreciation.

If desired only two groups may be used; i. e.,

Real estate and buildings.
Machinery and equipment.

SECTION VIII

DEPRECIATION

For convenience, the schedule of depreciation rates given in first bulletin is presented herewith for what assistance it may give.

It must be borne in mind, however, that new government rulings are constantly being made and that all rulings as to depreciation should be carefully watched.

DEPRECIATION SCHEDULE

When a piece of equipment outlives expected life, establish scrap value and make no further charge for depreciation.

	Per cent
A	
Alarm signal boxes	7½
Anvils	5 to 10
Arresters, lightning	10
Axes, fire	10
B	
Barrels, steel tumbling	10
Bathes, shower	10
Bearings, ordinary shaft hanger, babbitt	Expense
Bearings, roller, on line shaft	10
Belts, fast running—short life belts	Expense
Belts, lacing machines	10
Belts, main and ordinary drive	5 to 20
Benches, iron	5
Benches, wood	10
Bins, steel	5
Bins, wood	10
Blackboards, attached to wall	10
Blackboards on iron standards	10
Blower exhaust, laboratory	10
Blower system, furnaces	5
Boards, directory and planning	10
Boiler, steam power	5 to 7½
Boiler tube expanders	10
Boring machine, pattern	5
Boxes, annealing	Expense
Boxes, tote, steel	20
Boxes, tote, wood	Expense
Buildings, brick	2 to 5
Buildings, brick and wood	3 to 5
Buildings, concrete, reinforced	2 to 3
Buildings, steel frame, brick walls	2 to 3
Buildings, wood	5 to 10
Bumpers (See jarring machines)	10
Burners, gas—under boilers	5 to 7½
C	
Cars, annealing furnace	10 to 20
Cars, core oven	5
Cars, foundry trucking	10
Chemical laboratory apparatus	10
Chutes, loading and unloading	10 to 25
Clocks	4 to 10
Closets, toilet	10
Clutches, friction	10
Compressors, air	7½
Controllers, elect. circuit	10
Conveyors	10 to 20
Couplings, line shaft	10
Crane track	5

	Per cent
Cranes, swing	7½
Cranes, traveling	7½
Cupolas, steel	5
Cutters, bolt	5 to 10
Cutters, sprue	7½
Cutters, stencil	7½
Cutting apparatus, acetylene generation	10
Cutting apparatus, acetylene tools	Expense

D

Drill presses, multiple	7½
Drill presses, ordinary	5
Drinking fountains	10
Dust collecting systems	7½

E

Elevators	7½
Engines, steam or gas	4
Exhaust heads	5 to 10
Extractors, oil	5

F

Fans, ventilating	7½
Feeders, boiler compound	7½
Filters, oil	5
Fire apparatus	10
Flasks, aluminum	10
Flasks, cast iron	33⅓
Flasks, snap steel	12½
Flasks, wood	Expense
Flasks, wood, snap, metal bound	20 to Expense
Forges	5
Furnace, annealing	10
Furnaces, crucible—pit	7½
Furnaces, cupola—steel	5
Furnaces, electric	5 to 7½
Furnaces, open-hearth	10
Furniture and fixtures, general	10

G

Gages, steam recording	5
Gauges, steam	10
Glassware, laboratory	Expense
Glue heaters	10
Generators, electric	5
Grinders, bench, for castings	7½
Grinders, hand air	20
Grinders, hand electric	20
Grinders, swing for castings	10
Grinders, tool	5
Guards, for machines, belts, etc	10

H

Hangers, shaft	4
Heaters, boiler feed water	5
Heaters, foundry pot	10
Heating systems, hot air blower	6
Heating systems, steam	4
Hoists, air and hand	7½
Hoists, electric	10
Hoods, safety grinding wheel	5
Hose, air	Expense
Hose, fire	20
Hose, foundry	10
Hose, ladders, straps, etc	10

I

Injectors, boiler	10
Instruments, engineering and draughting department	5

J

	Per cent
Jackets for molds	Expense
Jacks, hand	10
Jacks, hydraulic	5
Jarring machines	10

K

Kettles, cast iron	10

L

Laboratory equipment, except glassware	7½
Laboratory equipment, glassware	Expense
Ladders, wood	Expense
Lanters, fire	20
Lathes	5
Lavatories	5
Lightning arresters	10
Lockers, steel	5

M

Machinery, general	5 to 10
Meters, electric	5
Meters, oil	7½
Meters, steam flow	10
Milling machines, according to kind	5 to 7½
Mixers, sand, Broughton type	10
Mixers, sand, Chile mill	7½
Molding machines, bench, Adams	7½
Molding machines, Berkshire	7½
Molding machines, rockover	5
Motors, electric	5

O

Oil separators	5
Ovens, core, brick	10
Ovens, core, steel	10
Ovens, drying, brick	10
Ovens, drying, concrete	5

P

Pans, steel tote	20
Patterns	10 to Expense
Pipe machine	5
Piping, air	5
Piping, fuel oil, overhead	5
Piping, fuel oil, underground	5 to 10
Piping, water and steam	5 to 7½
Planers, iron and wood	5
Plates, core	20 to Expense
Platforms for elevating trucks	Expense
Platforms, unloading	10
Plating machine, barrel	10
Pulleys, friction clutch	10
Pulleys, plain and split	5
Pumps, centrifugal water; if constantly used	20
Pump governors	5
Pumps, hydraulic	5
Pumps, steam	5
Pyrometers, thermoelectric	7½

NOTE: Piping underground—life governed by use and character of protection.

R

Racks, iron core	5
Racks, iron for iron and steel storage	5
Racks, iron, tool and tray	5
Racks, revolving iron	10
Racks, wood	10
Regulators, feed water	5
Regulators, voltage	10
Riddles, sand, core shop	20
Rumblers, steel	7½

S

	Per cent
Safety devices	10
Sand blast equipment	10
Sand mixer	See M
Saws, band, blades	Expense
Saws, band, machine	5
Saws, power	5
Scales, dormant	7½
Scales, platform	10
Sewers	2½
Shafting and hangers	4
Shapers	5
Shelving, steel	5
Shelving, wood	5 to 25
Signal boxes	7½
Sinks	10
Slip jackets and bands for molds	Expense
Sprinkler systems	3 to 7½
Sprue cutters	7½
Stacks, boiler and core ovens—steel	5 to 10
Stacks, brick	3
Stands, iron	5
Stands, wood	10
Steam separators	10
Steam traps	7½
Straightener for castings	10
Switch boards	4

T

Tables, coremakers'	7½
Tables, wood, general	10
Tables, wood, iron covered	7½
Tanks, iron acid	15
Tanks, iron air and oil	5
Tanks, fire bucket	10 to 25
Tanks, water, cement	5
Tanks, water, iron	10
Tanks, wood	10 to 25
Testing machines, tensile	5
Tool stands	See S
Tools, small	4 to 50
Tractors, electric	10
Transformers, electric power	4
Trucks, barrel	25
Trucks, electric	10
Trucks, elevating	10
Trucks, iron frame, 4-wheel	10
Trucks, wood, hand	25
Trucks, wood, 4-wheel	12½
Tumbling barrels—(See rumblers)	7½
Turntables	10

V

Valves, back pressure	5
Valves, reducing	7½
Valves, disk, brass	7½
Valves, gate, brass	5
Valves, gate, iron	10
Vises	10

W

Welding apparatus, acetylene, generation	10
Welding apparatus, acetylene, tools	Expense
Welding apparatus, electric, generation	5
Wheel barrows	50
Wire cutters	10
Wire measuring machine	5
Wire straightener	5
Wiring and fixtures, lighting	7½ to 10

SECTION IX
GENERAL LEDGER ACCOUNTS

The schedule of general ledger accounts on the following pages is such as would be required to reflect the details of an average foundry. Sub-accounts or additional accounts should be added to represent classes of transaction special to any particular foundry. The schedule and definitions are merely illustrative of the principles involved.

The accounts appear under the following groups which are in the sequence required for presentation on the balance sheet and profit and loss statement.

1. Current assets.
2. Inventory assets.
3. Fixed assets.
4. Deferred assets.
5. Intangible assets.
6. Current liabilities.
7. Fixed liabilities.
8. Reserves.
9. Capital liabilities.
10. Surplus and profit and loss accounts.
11. Financial profit and loss accounts.
12. Operating expense accounts.
13. Sundry general ledger accounts.

The following detailed accounts are suggested for the general ledger. These may be amplified as much as desired, or as the business demands.

1—*Current Assets:*

- 1—Cash in bank (an account for each bank).
- 2—Petty cash.
- 3—Notes receivable.
- 4—Accounts receivable.
- 5—Bonds and other investments

2—*Inventory Assets:*

- 1—Melting stock metals.
- 2—General stores (or as many as desired).
- 3—Finished castings.
- 4—Work in process.

3—*Fixed Assets:*

- 1—Machinery and equipment.
- 2—Real estate and buildings.

4—*Deferred Assets:*

- 1—Unexpired insurance.
- 2—Unexpired taxes.
- 3—Prepaid interest.

5—*Intangible Assets:*
  1—Patents.
  2—Good will.
6—*Current Liabilities:*
  1—Notes payable.
  2—Accounts payable.
  3—Accrued payroll.
  4—Accrued taxes.
  5—Accrued commission.
  6—Accrued interest.
7—*Fixed Liabilities:*
  1—Bonds payable.
  2—Mortgages payable.
8—*Reserves:*
  1—Reserve for depreciation on machinery and equipment.
  2—Reserve for depreciation on buildings.
  3—Reserve for bad debts.
9—*Capital Liabilities:*
  1—Capital stock—preferred.
  2—Capital stock—common.
10—*Surplus and Profit and Loss Accounts:*
  1—Surplus.
  2—Income and excess profits account.
  3—Dividends—preferred stock.
  4—Dividends—common stock.
  5—Profit and loss
  6—Adjustment account.
  7—Castings sales.
  8—Cost of castings sales.
  9—Miscellaneous sales.
  10—Cost of Miscellaneous sales.
  11—Freight out on sales.
  12—Administrative expense.
  13—Selling expense.
11—*Financial Profit and Loss Accounts:*
  1—Interest received.
  2—Discount taken.
  3—Interest paid.
  4—Discount given.
  5—Interest on investments.
12—*Operating Expense Accounts:*
  1—Cost of melt.
  2—Cost of melt credits.
  3—Molding burden—direct labor.
  4—Molding burden—direct labor credits.
  5—Molding burden—machine hour.
  6—Molding burden—machine hour credits.
  7—Molding sand cost.
  8—Molding sand cost credits.
  9—Flask cost.
  10—Flask cost credits.
  11—Coremaking burden—direct labor.
  12—Coremaking burden—direct labor credits.
  13—Coremaking burden—machine hour.

14—Coremaking burden—machine hour credits.
15—Finishing cost.
16—Finishing cost credits.
17—Annealing cost.
18—Annealing cost credits.
19—Power, heat and light expense.
20—Pattern shop expense.
21—General expense.
22—Expense ledger.

13—*Sundry General Ledger Accounts:*

1—CURRENT ASSETS

(1-1)—*Cash in Bank:*

Debits—

(1) Open the account with the amount of cash in bank;
(2) Total amount of cash deposited during the month.

Credits—

(1) Total amount of checks issued during the month.

Balance—

Represents value of cash in bank at end of month. Should be reconciled with bank's statement to determine outstanding checks and uncredited deposits.

(1-2)—*Petty Cash:*

Debits—

(1) With the value of checks drawn to create or to increase the amount of cash on hand to cover petty expenses for a short period.

Credits—

(1) With any decrease in the amount on hand.

Balance—

Represents amount set aside for petty cash disbursements.

(1-3)—*Notes Receivable:*

Debits—

(1) Open the account with the face value of promissory notes and acceptances on hand;
(2) Notes and acceptances received;
(3) Notes renewed.

Credits—

(1) Payments on notes receivable and acceptances;
(2) All notes and acceptances sold or otherwise disposed of;
(3) All notes renewed.

Balance—

Represents value of all notes receivable and acceptances on hand.

(1-4)—*Accounts Receivable:*

Debits—

(1) Open the account with the total of individual customers' accounts in the accounts receivable ledger.
(2) The total charges to customers as represented by postings on sales register.

Credits—

(1) Total payments received from customers, whether cash, notes or acceptances.

(2) Allowances to customers, including cash discount; in other words, the gross settlements with customers.

Balance—

Represents the net amount due from customers.

(1-5)—*Bonds and Other Investments:*

Debits—

(1) Open the account with the market value of stocks and bonds on hand;
(2) Market value of other investments.
(3) Cash value of life insurance policies, etc.;
(4) Cost of all stock, bonds and other investments purchased.

Credits—

(1) Cost of stocks, bonds and other investments sold at value carried (profit or loss debits or credits profit and loss on investments).

Balance—

Represents cost value of stocks, bonds and other investments owned by the company.

2—INVENTORY ASSETS

(2-1)—*Melting Stock—Metals:*

Debits—

(1) Open the account with the cost value of all melting stock or metals on hand;
(2) All purchases of melting stock metals;
(3) Transportation charges on incoming melting stock metals (distributable according to corresponding invoices);
(4) Unloading charges if a long term supply;
(5) Returns to stores of melting stock from melting department.

Credits—

(1) All withdrawals of melting stock metals as represented by monthly summary of metals used;
(2) All melting stock returned to vendors.

Balance—

Represents the value of melting stock metals on hand and should agree with the aggregate of the individual stock ledger sheets or cards.

Note:—The following sub-divisions may be maintained:

1. Pig iron.
2. Purchased scrap.
3. Foundry scrap.
4. Ferromanganese.
5. Ferrosilicon.
6. Other melting stock as required.

(2-2)—*General Stores:*

Debits—

(1) Open the account with the value of all general stores material (i. e., other than melting stock metals) on hand;
(2) Purchases of additional material;
(3) Transportation charges on incoming general stores material (distributable according to corresponding invoices);
(4) Returns to stock of general stores material.

Credits—

(1) Withdrawals of general stores material from stock as represented by monthly summary of materials used;

(2) Material returned to vendors.

Balance—

Represents the book value of general stores material on hand and should agree with the aggregate of the individual stock ledger sheets or cards.

(2-3)—*Finished Castings:*

Debits—

(1) Open the account with the physical value of all finished castings on hand;

(2) Deliveries of finished castings as represented by the summary of closed production orders—at cost;

(3) Returns of good material from customers.

Credits—

(1) Material shipped during the period as represented by summary of reports of shipments;

Balance—

Represents cost value of finished goods on hand.

(2-4)—*Work in Process:*

Debits—

(1) Open the account with cost of goods in process;

(2) With the total amount of molding productive labor and coremaking productive labor as represented by the summary of time cards on pay rolls;

(3) With cost of melt for the month at predetermined rate;

(4) With proper portion of following expense accounts at predetermined rates:

a. Molding burden—direct labor,
b. Molding burden—machine hour,
c. Molding sand cost,
d. Flask cost,
e. Coremaking burden—direct labor,
f. Coremaking burden—machine hour,
g. Finishing cost,
h. Annealing cost;

(5) With cost of castings returned by customers (if finished castings account not carried).

Credits—

(1) Cost of castings shipped, if finished castings account not carried, otherwise with cost of finished castings delivered to finished castings stores;

(2) Scrap value of bad castings and sprues returned to melting metals stock;

(3) Losses due to defective work or other errors in service distributable to the departmental expense involved.

Balance—

Represents cost of finished castings on hand and in process (if finished castings account not carried), otherwise of castings in process.

3—FIXED ASSETS

(3-1)—*Machinery and Equipment:*

(3-2)—*Real Estate and Buildings:*

Debits—

(1) Open the accounts with the first cost or replacement value of all permanent plant investment represented by the respective accounts;

(2) All expenditures for permanent additions.

Credits—

(1) Value of fixed assets sold, disposed of or otherwise taken out of service.

Balance—

Represents book value of fixed assets against which as offsetting accounts are the respective reserves for depreciation.

4—DEFERRED ASSETS

(4-1)—*Prepaid Insurance:*

Debits—

(1) Open the account with the amount of unexpired insurance premiums;

(2) Subsequent insurance premiums.

Credits—

(1) Periodical charge equivalent to pro rata insurance cost for period;

(2) All refunds and cancellations.

Balance—

Represents unexpired insurance premiums.

(4-2)—*Prepaid Taxes (if prepaid—see* 6-4)*:*

Debits—

(1) Open the account with total of unexpired taxes paid in advance;

(2) Subsequent taxes paid in advance.

Credits—

(1) Amount equivalent to one-twelfth the annual tax to effect liquidation of monthly charge to taxes in the various expense groups.

Balance—

Represents taxes paid in advance.

(4-3)—*Prepaid Interest (See* 6-6)*:*

Debits—

(1) Open with balance of prepaid interest;

(2) All subsequent prepaid interest.

Credits—

(1) With monthly proportions of interest accrued as to the items entered in this account as prepaid.

Balance—

Inventory of unused prepaid interest.

5—INTANGIBLE ASSETS

(5-1)—*Patents:*

Debits—

(1) Open the account with the estimated value of patents owned;

(2) Cost of acquiring subsequent patents including all incidental expenses.

Credits—
(1) Pro rata amount equivalent to one-twelfth the annual charge for the extinguishment of patents. (If so treated.)

Balance—
Represents book value of patents owned.

(5-2)—*Good Will:*

Debits—
With value of good will.

Credits—
With any depreciation of same.

Balance—
Net value of good will as carried.

6—CURRENT LIABILITIES

(6-1)—*Notes Payable:*

Debits—
(1) • Payments reducing the notes payable.

Credits—
(1) Open the account with the value of all outstanding notes payable;
(2) All subsequent notes issued.

Balance—
Represents amount owed by the company on notes payable.

(6-2)—*Accounts Payable:*

Debits—
(1) Payments of accounts payable;
(2) With all contra charges to vendors' accounts;
(3) Value of material returned to vendors for credit;
(4) With amount of notes given vendors;
(5) With all trade or cash discounts allowed by vendors and earned.

Credits—
(1) Open the account with the total of vendors' or purchase creditors' accounts;
(2) Total credits to accounts payable on the purchase journal.

Balance—
Represents net amount owed to creditors on open account.

(6-3)—*Accrued Pay Roll:*

Debits—
(1) Amount of wage and salary payments made during the period as represented by cash book entries;
(2) With amounts paid as bonus.

Credits—
(1) Amount of wages, salaries and bonus earned during the period.

Balance—
Represents pay roll amounts accrued but unpaid.

(6-4)—*Accrued Taxes (If accrued—See* 4-2)*:*

Debits—
(1) Actual payment of taxes.

Credits—
(1) Monthly amount charged to operating expense.

Balance—

Represents accrued amount of taxes accumulated but not yet due.

(6-5)—*Accrued Commissions:*

Debits—

(1) Commissions actually paid agents or sales representatives.

Credits—

(1) All accrued commissions on sales billed (or orders taken) during the period, charging selling expenses.

Balance—

Represents commissions accrued but not paid.

(6-6)—*Accrued Interest* (*See* 4-3):

Debits—

(1) With interest paid as to items entered herein as accrued.

Credits—

(1) Open the account with the amount of accrued interest unpaid

(2) With amounts accrued monthly on items where interest is accruing.

Balance—

Represents accrued interest on items payable accumulated but not yet paid.

7—FIXED LIABILITIES

(7-1)—*Bonds Payable:*

Debits—

(1) Payments reducing same.

Credits—

(1) Open with balance of all outstanding bonds;

(2) With all subsequent issues.

Balance—

Represents outstanding bonded indebtedness.

(7-2)—*Mortgages Payable:*

Debits—

(1) Payments reducing the principal of mortgages payable.

Credits—

(1) Open the account with the total amount due on the principal of all mortgages payable;

(2) Mortgages subsequently issued.

Balance—

Represents total amount owing on mortgages payable.

8—RESERVES

(8-1)—*Reserve for Depreciation on Machinery and Equipment:*

(8-2)—*Reserve for Depreciation on Buildings:*

Debits—

(1) With that portion of the cost which has been depreciated of anything replaced or sold.

Credits—

(1) Open the account with the amount of reserve allowed for depreciation;

(2) Depreciation charge to departmental or general expenses equivalent to a pro rata amount of the annual depreciation charge.

Balance—

Represents the allowance for depreciation of permanent plant investments and maintained as offsetting accounts to the respective fixed asset accounts.

Note:—If the present net book value (first cost less depreciation amount) cannot be determined for any particular article replaced, the first cost should be credited to the fixed asset account and charged to the corresponding reserve for depreciation. If, however, the article replaced is sold or otherwise disposed of at a scrap value, the first cost should be credited to the fixed asset account and first cost less scrap or exchange value should be charged to the corresponding reserve for depreciation. The scrap value should, of course, be charged to the purchaser.

(8-3)—*Reserve for Bad Debts:*

Debits—

(1) With value of accounts receivable considered uncollectable, crediting the individual customers' account so written off.

Credits—

(1) Open the account with an amount considered sufficient to cover all losses on accounts considered uncollectable;

(2) Amount based on a percentage of sales billed to provide for losses on amounts charged during the period.

Balance—

Represents allowance reserved for losses on accounts receivable.

9—CAPITAL LIABILITIES

(9-1)—*Capital Stock—Preferred Issued:*

(9-2)—*Capital Stock—Common Issued:*

Debits—

(1) With the par value of stock returned to or acquired by the company.

Credits—

(1) With the par value of stock outstanding.

Balance—

Represents the par value of issued capital stock outstanding, preferred and common, respectively.

10—SURPLUS AND PROFIT AND LOSS ACCOUNTS

(10-1)—*Surplus:*

Debits—

(1) With the amount of dividends at annual closing.

(2) With amount transferred from profit and loss (if loss) at annual closing period.

Credits—

(1) Open the account with the amount of undivided profits;

(2) With profits made during the current year transferred from profit and loss at annual closing.

Balance—

Represents undivided profits, if a credit.

Represents deficit, if a debit.

Note:—Make *no* entries to surplus account except at annual closing time.

(10-2)—*Income and Excess Profits Tax Account:*

Debits—

With amount of income and excess profits tax paid.

Credits—

With any necessary adjustments.

Balance—

Represents amount of income and excess profits taxes paid.

(10-3)—*Dividends—Preferred Stock:*

Debits—

(1) With the amount of dividends paid.

Credits—

(1) With debit to surplus at close of year.

Balance—

Represents dividends paid.

(10-4)—*Dividends—Common Stock:*

Debits—

(1) With the amount of dividends paid.

Credits—

(1) With debit to surplus at close of year.

Balance—

Represents dividends paid.

(10-5)—*Profit and Loss*

At Annual Closing Time:

Debits—

(1) With debit balance of cost of castings sales;
(2) With debit balance of cost of miscellaneous sales;
(3) With debit balance of freight out on sales;
(4) With debit balance of administrative expenses;
(5) With debit balance of selling expenses;
(6) With debit balance of interest paid;
(7) With debit balance of discount given;
(8) With net amount of plant balances (Operating expense accounts Nos. 12-1 to 12-18 inclusive) if such amounts are debit balances;
(9) With debit balance of adjustment account.

At Annual Closing Times:

Credits—

(1) With credit balances of castings sales billed;
(2) With credit balance of miscellaneous sales;
(3) With credit balance of interest received;
(4) With credit balance of discount taken;
(5) With credit balance of interest on investments;
(6) With net amount of plant balances (operative expense accounts 12-1 to 12-18 inclusive) if such amounts are credit balances;
(7) With credit balance of adjustment account.

Balance—

Represents net profit or loss resulting from transactions of the period accumulated and should be transferred at end of the fiscal year to surplus.

(10-6)—*Adjustment Account:*

Debits—

(1) With any determinable decrease in any particular account not traceable to some other account;

(2) With necessary adjustments of any nature.

Credits—

(1) At closing periods with any determinable increase in any particular account not traceable to some other account.

(2) With necessary adjustments of any nature.

Balance—

Represents adjustments necessarily made.

(10-7)—*Castings Sales:*

Debits—

(1) With the billed amount of castings returned by customers;

(2) With allowances to customers as represented by credit memoranda if a sale reduction;

(3) With credit balance, transferring to profit and loss at annual closing time.

Credits—

(1) Total casting sales billed during the month as represented by the sales register, charging accounts receivable.

Balance—

Represents net sales billed.

(10-8)—*Cost of Casting Sales:*

Debits—

(1) Cost value of all material shipped as represented by summary of daily reports of shipments.

Credits—

(1) Cost of material returned by customers during the period;

(2) With the debit balance at the end of closing periods charging profit and loss.

Balance—

Represents net factory cost of shipments.

(10-9)—*Miscellaneous Sales:*

Debits—

(1) With value at sale price of any returned sales.

Credits—

(1) With sale value of any nature other than castings sales.

Balance—

Value of miscellaneous sales.

(10-10)—*Cost of Miscellaneous Sales:*

Debits—

(1) With cost of above sales.

Credits—

(1) With cost of any returned sales.

Balance—

Net cost of miscellaneous sales.

(10-11)—*Freight Out On Sales:*

Debits—

(1) With all payments of transportation of any nature for delivery of goods to customers.

Credits—
(1) With necessary adjustments.
Balance—
Net cost of delivering sales to customers.

(10-12)—*Administrative Expenses:*
Debits—
(1) With the aggregate of charges to all expense accounts classified as administrative expenses.
Credits—
(1) With debit balance at closing periods charging profit and loss.
Balance—
Represented aggregate of administrative expenses.

(10-13)—*Selling Expenses:*
Debits—
(1) With the aggregate of charges to all expense accounts classified as selling expenses.
Credits—
(1) With debit balance at closing periods charging profit and loss.
Balance—
Represented aggregate of selling expenses.

11—FINANCIAL PROFIT AND LOSS ACCOUNTS

(11-1)—*Interest Received:*
Debits—
(1) With necessary adjustments.
Credits—
(1) With all interest received for balances or overdue accounts.
Balance—
Net interest received.

(11-2)—*Discount Taken:*
Debits—
(1) With credit balance, transferring to profit and loss.
Credits—
(1) With all cash discounts earned; does not include trade discounts.
Balance—
Represents cash discounts earned.

(11-3)—*Interest Paid:*
Debits—
(1) At closing periods with the amount of interest accrued for the month on items payable, crediting accrued interest or prepaid interest.
Credits—
(1) With debit balance, transferring to profit and loss.
Balance—
Represents amount of interest actually incurred.

Note:—If interest is prepaid, the payment should be charged to prepaid interest (Acct. 4-3). The amount should be liquidated in monthly amounts to apportion the charge equitably over the

periods involved. Likewise, watch for action of accruing interest as explained in Account 6-6.

(11-4)—*Discount Given:*

Debits—

(1) Cash discounts allowed customers—does not include trade discounts.

Credits—

(1) With debit balance, transferring to profit and loss.

Balance—

Represents cash discounts allowed.

(11-5)—*Interest or Dividends on Investments:*

Debits—

(1) With necessary adjustments.

Credits—

(1) With interest or dividends received on investments. This should be treated as separate from regular commercial interest.

Balance—

Net results of regular income from outside investments.

12—OPERATING EXPENSES

Explanatory Note:

Accounts 12-1 to 12-18 inclusive cover the actual operating accounts; i. e., those that appear in the actual cost sheet, either by pound or percentage.

If reference is made to the skeleton statements, it will be noted that "Total to Date" is used, both in the body of the statement and in the comparative monthly statement.

It is quite evident, therefore, that if we should have but one account for each burden and cost statement, and credit this with the transfer at predetermined rates to work in process, we would have no easy way of securing our "To date" figures.

In order to make this easy, we have two ledger accounts for each expense or burden account.

One, bearing simply the name of the account, is for *debits only,* except where a credit is necessary to *adjust or correct the debits.*

The other, bearing the account name followed by "Credits," is for *credits only* of the transfers to work in process, except when a debit may be necessary to *adjust or correct the credits.*

The result of this is that we have an accumulating figure for each kind of account which gives us from the general ledger trial balance the figures to use in our statements of "Total to Date" the monthly figures coming from our footings for the month's transactions, which *must* balance with the entries for the month in the ledger account controlling each expense account.

It is quickly seen, therefore, that the difference between the "debit" and "credit" account for each expense account is the over or under absorbed expense, and will and *must* agree with the monthly statements.

* * * * * *

Accounts 12-19 to 12-22 inclusive need but a single account as they are to be *entirely closed out* each month, being simply collective accounts as a medium to split down these expenses to the actual operating accounts.

* * * * * * *

(12-1)—*Cost of Melt:*

Debits—

(1) Melting stock metals used (requisitions).
(2) Labor (time cards).
(3) Miscellaneous materials (requisitions).
(4) Charges direct from purchase register (expense ledger charge slips).
(5) Apportioned charges.

Credits—

(1) Adjustments of debits only.

(12-2)—*Cost of Melt—Credits:*

Debits—

(1) Adjustments of credits only.

Credits—

(1) Value of metal poured at the standard predetermined rate.

(12-3)—*Molding Burden—Direct Labor:*

Debits—

(1) Labor (time cards).
(2) Materials (requisitions).
(3) Charges direct from purchase journal (expense ledger charge slips).
(4) Apportioned charges

Credits—

(1) Adjustments of debits only.

(12-4)—*Molding Burden—Direct Labor—Credits:*

Debits—

(1) Adjustment of credits only.

Credits—

(1) Amount equal to molding direct labor x standard rate.

(12-5)—*Molding Burden—Machine Hour:*

Debits—

(1) Labor (time cards);
(2) Materials (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges of power and depreciation.

Credits—

(1) Adjustment of debits only.

(12-6)—*Molding Burden—Machine Hour—Credits:*

Debits—

(1) Adjustments of credits only.

Credits—

(1) Amount equal to actual machine hours used x standard rate per hour.

(12-7)—*Molding Sand Cost (If used):*

Debits—

(1) Labor (time tickets);
(2) Materials (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips).

Credits—

(1) Adjustments of debits only.

(12-8)—*Molding Sand Cost—Credits (If used):*

Debits—

(1) Adjustments of credits only.

Credits—

(1) Amount equal to total metal poured x standard rate per pound.

(12-9)—*Flask Cost (If used):*

Debits—

(1) Labor (time tickets);
(2) Materials (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) With total monthly charges in pattern shop expense accounts Nos. 704 and 705 (by transfer).

Credits—

(1) Adjustments of debits only.

(12-10)—*Flask Cost—Credits (If used):*

Debits—

(1) Adjustments of credits only.

Credits—

(1) Amount equal to total good castings x standard rate per pound.

(12-11)—*Coremaking Burden—Direct Labor:*

Debits—

(1) Labor (time tickets);
(2) Material (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges.

Credits—

(1) Adjustments of debits only.

(12-12)—*Coremaking Burden—Direct Labor—Credits:*

Debits—

(1) Adjustments of credits only.

Credits—

(1) Amount equal to coremaking direct labor x standard rate.

(12-13)—*Coremaking Burden—Machine Hour:*

Debits—

(1) Labor (time tickets);
(2) Material (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges.

Credits—

(1) Adjustments of debits only.

(12-14)—*Coremaking Burden—Machine Hour—Credits:*

Debits—

(1) Adjustments of credits only.

Credits—

(1) Amount equal to actual machine hours used x standard rate per hour.

(12-15)—*Finishing Cost:*

Debits—

(1) Labor (direct and indirect unless in large plants) (time tickets);

(2) Material (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges.

Credits—
(1) Adjustments of debits only.

(12-16)—*Finishing Cost—Credits:*

Debits—
(1) Adjustments of credits only.

Credits—
(1) Amount equal to molding and core direct labor x standard rate.

(12-17)—*Annealing Cost:*

Debits—
(1) Labor (time tickets);
(2) Material (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges.

Credits—
(1) Adjustments of debits only.

(12-18)—*Annealing Cost—Credits:*

Debits—
(1) Adjustments of credits only.

Credits—
(1) Amount equal to total good castings x standard rate.

(12-19)—*Power, Light and Heat:*

Debits—
(1) Labor (time cards);
(2) Material (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges.

Credits—
(1) With total net balance at the close of each month distributed on a percentage or other basis to the various operating accounts as explained elsewhere.

Balance—
There should be no balance.

(12-20)—*Pattern Shop Expense:*

Debits—
(1) Labor (time tickets);
(2) Materials (requisitions);
(3) Charges direct from purchase journal (expense ledger charge slips);
(4) Apportioned charges.

Credits—
(1) With amount in order 702 charging molding burden—direct labor.
(2) With amount in order 703 charging coremaking burden—direct labor.
(3) With amounts in orders 704 and 705, charging flask cost.
(4) With amount of residue as directed.

Balance—

There should be no balance.

Note:—If pattern shop is operated as a producing department, and not solely as a co-operating department, the accounting shall be changed to correspond to the condition and provision made for:

1—Pattern production orders;
2—Pattern productive labor;
3—Pattern shop expense account;
4—Pattern work in process material and cost compilation changed accordingly.

(12-21)—*General Expense:*

Debits—

(1) Labor (time tickets);
(2) Material (requisitions);
(3) Charges direct from purchase journal (expense ledger debit slips);
(4) Apportioned charges.

Credits—

(1) With total net balance at end of each month distributed on the prescribed basis to each operating account.

Balance—

There should be no balance.

(12-22)—*Expense Ledger Account:*

Debits—

(1) At end of each month with total of charges made direct to operating accounts, which charges are represented by expense ledger charge slips.

Credits—

(1) With the total of expense ledger charge slips charging the various operating accounts.

Balance—

If any balance exists, it is in error, and the charge slips in the files for month should be checked back to the purchase journal.

13—SUNDRY GENERAL LEDGER ACCOUNTS

In this section of the ledger will be located all sundry accounts with firms and individuals, irrespective of whether their balance is debit or credit.

There are always a certain number of accounts that float around without any particular home, and this is the place to put all such.

When making up a statement, the accounts classify themselves according to their balance into two classes, i. e.:

General ledger accounts receivable;
General ledger accounts payable.

They will be so entered in the statements immediately under the accounts receivable, and accounts payable respectively.

COMMENTS REGARDING STARTING COST WORK

While these comments are in numbered sequence, practically all may and should be handled at once.

First:—Get your house in order.

(a) Clean up your shop.

(b) See that a day's work goes through your entire shop in a day—that is—that each department is so tuned up with the others that there is a steady flow of work. Above all things, see that all work goes through and out of shop in sequence of the originating pouring of castings, *except* that you provide storage or accumulation points for the sorting and classifying of like castings in order to put them through finishing operations in lots.

(c) The foregoing is absolutely necessary; system or no system of costs, as it is only good business. But no system of costs or production follow up is worth a snap of a finger unless the plant is onto its job as to orderliness, and common everyday clean cut handling of its details.

Second:—Get your raw materials and supplies under proper storage control. If you have no stock room—build one. Why should you pay your good money for material—and then let anyone at all dip in to their hearts' content?

Third:—Get a clock for all employes to ring *in* and *out* on, so that you have some sound basis for timekeeping.

* * * * * *

When you get squared away, with materials in stock rooms, and your pig iron, etc., in order, then start records.

Fourth:—It is most important to have a proper production order. Never mind what it is if you provide for telling your shop what and how many to make. While doing this, provide a method to record *what is made,* so that you know in each department just how your work is progressing. See how easy it is when your shop *keeps* it *going.*

Fifth:—Start time cards. Best to be 3″ x 5″ for easy filing. One job of one man for one day only to a time card. If possible, have your time recorded by timekeeper. Bad busi-

ness depending on a laborer to be a record keeper; besides it's *cheaper* to *specialize* clerical work vs. mechanical.

Sixth:—Put into use the code of expense order shown herewith. You will delight in knowing where your money is going.

Seventh:—Let no material be used without a record. Requisitions 4″ x 6″ are best, as they fit a standard file—get an old crank for a storekeeper and he will pay for his salary many times over in reduced material costs.

Eighth:—Provide a *real man* to handle your costs. One who understands the plant operations, and who understands the office end. *It will pay*—and pay well. Cost work is not a boy's job, and if made so had better be left alone.

* * * * * *

Remember this. The finding of costs accomplishes two things:

First:—Tells you what you must charge for your goods to make a profit.

Second:—And perhaps the greater point of the two, it tells you just where your money goes—and if you go at it in a red-blooded way, you can make large cuts in your costs.

Forms? The least part of the game, except to have them the best for economical handling. The forms are the vehicles only of what you collect. The biggest thing is to *get behind it*—everyone pulling the same way, realizing that costs *must be known*.

Index—A. F. A. Cost Accounting System

Industrial Democracy and the Foreman

By John Calder, New York.

During the past twelve months it has been the privilege of the writer to confer with several thousand executives and foremen affiliated with industries located in 10 different states. These industries included foundries, machine shops, iron and steel mills and workers in wood, rubber, leather, textiles, jewelry and wearing apparel. These conferences were a part of an educational program for executives and foremen undertaken in private groups usually embracing the complete staff of one plant at a time, though several meetings were in the nature of joint conferences with some hundreds present.

The object of this paper is to present some account of how our executives and foremen are being taught to think about industrial relations and what reactions they have with the workman in regard to his status and claims for consideration. The writer believes that all machinery for improving the relations between capital and labor should be based upon knowledge and a correct analysis of the facts and that these should be obtained from the original sources and not assumed as is too often the case.

What Then are the Facts?

What, then, are the facts revealed by these numerous contacts and the very frank expression of opinion and experience which obtains in such private gatherings for economic education?

In such meetings the spirit of the age is clearly manifest. History shows that great economic and social forces flow like a tide over communities only half conscious of that which is befalling them. Wise statesmen and business men are

those who foresee what time is thus bringing, and try to shape institutions and mold men's thought and purpose in accordance with the change that is silently surrounding them.

The unwise are those who bring nothing constructive to the process and who greatly imperil the future of mankind by leaving great questions to be fought out between ignorant change on one hand and ignorant opposition to change on the other. Happily the spirit of change, in industry at least, is constantly becoming better informed, and we demand that all programs of reconstruction be submitted to the test of economic soundness. Nevertheless we must be prepared for change. Political democracy is now recognized to be fundamentally dependent upon industrial democracy. The latter is inevitable in our social evolution but it has no terrors for the open-minded student of affairs. It is not revolutionary but the harbinger of peace and co-operation.

We can no longer live industrially in compartments. The safety man, the foundry foreman, the employment manager and all others who touch industry on its social side must, in the opinion of the writer, fuse their efforts effectively with other foremen, superintendents, employers and employes on a plan that permits of self-expression and self-determination on the part of the workman in everything that touches his industrial interests.

The Program of the Age

The spirit of the age discloses an increased moral sensitiveness and a development of public conscience in every walk of life. The program of the age is the conservation of all material and vital resources and the program of industry is the more efficient use of that which has been conserved and a demand that service to society shall be the sole basis of its distribution.

The progress of science which did so much for the nineteenth century and for civilization gave us something much greater, namely, the scientific spirit, with its scrupulous verification, its intellectual morality, its serenity and its habitual resnonse to any disclosure of the truth. This is the

spirit which has now invaded industry and it cannot be restricted to the mechanical ways and means of efficient production. It reaches out to the morals and manners of industry and demands the truth, the whole truth and nothing but the truth about all the people, things and policies involved.

To some this is a disturbing prospect but to those whose motto is "To make goods plentiful and men dear" it is an earnest that they will succeed. Too many are concerned today about only one or the other of these objects but there is no satisfying future unless we aim at and attain *both* and the proved economies of specialized large-scale production are indispensable to our modern civilization.

Industry Must Be Democratic

When we do so realize that, modern production methods at their best, though calculated to increase individual and national well-being, will not of themselves produce industrial contentment. Economic friction, even in the best-ordered industrial families, is the inevitable price we must pay for a democratic basis of existence and the great majority of us are convinced that it is well worth the price. In fact we have really no choice in the matter. It is quite useless in our day to fence off any large portion of human activities and interests and declare that self-expression and self-determination may not operate there. Yet the plain facts of our industrial relations are so over-laid by various theories of reconstructing them that the public and many executives are bewildered and are asking for a precise answer to the question, "What does the workman want?"

It is of the essence of good management and foremanship to be able to answer this question and to arrive at sound ideas as to the reasonableness of these wants, and as to the possibility of meeting them in a way which will insure general prosperity instead of weakly yielding to force or political pressure on opportunist issues. Most of us are intimately connected with industry and have been so all our lives, and we know that, while details may be lacking here

and there, there is no difficulty in sympathetically interpreting the workman's mind when you live in close contact with him.

What the Workman Wants

The facts about modern management and industrial unrest are briefly these: Not due primarily to the great war but simply intensified by it, the worker is putting forward new claims for consideration and also some old ones which had not been generally conceded.

The workman demands more liberty in industry—a share in the policies of management so far as they touch his interests. In so doing he rarely adopts any one of the schemes of social reconstruction which are pressed upon his attention today, nor does he mean to dispense with or overrule the superior ability, knowledge and experience admittedly necessary in the general conduct of a plant by its managers and owners.

There are schemes which propose to lay violent hands on all capital with no adequate care for skilled direction but the workman's desire is for a change in the *spirit* of industry and that change is being welcomed by all thoughtful owners and executives.

The workman wants to be treated as an intelligent participator in industry, not merely as the seller of a commodity. He wants to be consulted, to have some things explained to him in the first instance, not merely thrown at him or arbitrarily imposed on him by bulletins, orders or decisions to which he was not a party.

To this the employer and foreman, still mentally in the last century, say "Can't we do anything we *like* with our *own* things and plans in our *own* plant?" The answer is that there is no law against trying it but that, if we are wise, we won't attempt to play a lone hand with the personal interests of others.

This desire of the workman is often voiced in his own plant, and to his own foreman, even when it does not reach his employer, and it is always latent today. Too often, for lack of an opportunity to express himself to his employer,

it is voiced for him by people outside of his daily round, some of whom misrepresent him and are not at all scrupulous about writing between the lines things which the workman is not asking for.

The desire of the workman to have such representation as he pleases on all matters affecting him seems a reasonable and laudable claim and employers following modern production methods and management at their best must concede it. If they are wise they will welcome it, and those who are do so.

Obstacles to Progress

When the machinery in any plant does not exist for easy expression of employe opinion and desire, or when supervisors and foremen deal arbitrarily with it, workmen are gradually convinced that democracy is forbidden and are driven to express themselves through outside organization and mass action upon issues which sometimes concern only a few of their number. Often such a result is the effect of deliberate company policy, but sometimes the supervisor undertakes to suppress employe opinion for a while, only to have a more serious issue ultimately forced upon his employer through his mistaken action.

Instances of all these difficulties which emerged in class conferences and investigation, shows that the employer is usually at fault for the existence of foremen who feel that repression will be tolerated if they can only "put it over." Some collapses in apparent industrial stability have been proved to be due to the death or sudden withdrawal of such men of commanding personality at critical moments in the history of a concern.

Under such conditions, exasperated and suspicious massed employes are able at times to exert great power without responsibility and without much regard to the merits of the original demand. Employers have suffered greatly under this head, nevertheless the ultimate remedy is not to fight and, if possible, defeat such organized forces in your own plant but to confer real responsibility by taking your people into

consultation. This may seem an obvious procedure but on the testimony of many foremen it is frequently omitted.

What is Happening Abroad

One of the features of my conferences with foremen and managers has been their deep interest in what is happening to industry abroad and it is important that they should understand the situation there and should realize the way out for American industry in its much happier circumstances.

In spite of various optimistic reports the fact is that industry abroad has entered upon a stormy and dangerous sea. In any case it would have had to face serious problems but the war has accentuated everyone of them. The reframing of the social order and the readjustment of industrial relations there will take years and will prove a severe test but it must be carried through so as to satisfy the social aspirations of the democratic peoples involved.

In so doing it will doubtless have to shed many programs inconsistent with the industrial efficiency upon which our modern civilization wholly depends, and we need not be unduly alarmed at the radical nature of the first drafts of some of these programs. In England at least there has been for many years a highly intellectualized socialist program which has never materialized.

Much justifiable discontent, however, exists abroad which has no reasonable counterpart here. Some of it is temporary and due to the unavoidable stagnation and disorganization after the war amongst nations whose productive energies and liberties were monopolized for defense purposes to an extent of which we have no conception. Those of us who were in France in the dark days of 1916-17 realized what general arrest of normal industry meant.

But some of the present industrial friction abroad is due to prewar grievances which were never adjusted and the work people of England who, out of patriotism, postponed their desires for five long years full of sacrifice, are in an ugly mood, not conducive to wise action. At the same time they are being served by men of great shrewdness and intel-

lectual ability who made short work of the weak defenses of employers, whose case for private operation of industry was very inadequately presented.

Incited by clever, eloquent advocates of attractive schemes claiming to provide more wealth for all by less work, and moved to indignation by some of the disclosures regarding mining conditions, these people have endorsed the most fallacious doctrines and are liable to become the victims of hastily conceived and ill-advised reforms for which their legislatures have received no mandate from the people at large.

Such is the condition across the Atlantic where the whole social well-being is in the melting pot and industry is marking time. Russian industrial policy is a thing apart, a crazy-quilt the making of which demands the close attention of American engineers, employers and employes, if our industrial relations are to be kept sane and our industrial democracy not merely an attractive screen for gross tyranny.

What is Happening in America

What of American industry? Contrasted with European, the members of these executive conferences say regarding the war, "It never touched us." Yet of the European industrial unrest we have more than echoes here, though we are prosperous far beyond our anticipations of a year ago. We have every prospect of greater prosperity if we keep our heads and bend our backs to producing the goods and services which are now so scarce and dear, instead of loafing on the job and trying to cut corners.

Some of our plants are, possibly, in too great a hurry to substitute copies of the representative machinery which became fashionable and almost a necessity abroad during the war, for the slower and less showy process of economic education as the solution for industrial friction. The latter combined with utter frankness on the part of employers toward labor will go far toward harmony.

This much at least is probable, that hopeful expectations from the institution of works' councils and of committee

representations, can only be reasonably entertained when the foremen and executives who represent the ownership in such bodies are competently informed, energized, sympathetic and keenly desirous to get at the truth and to solve all difficulties on the sound economic grounds which alone insure permanent settlements.

Economic Education of Foremen Essential

An analysis of the intelligence and perceptions of the many executives with whom personal contacts have been made has convinced the writer that they will never be educated economically merely by membership in such councils. It is absolutely necessary that our foremen should bring economic education *into* such meetings.

Some of the smaller employers need the training as much as do their men and all employers would benefit from hearing their foremen talk out in the privacy of the family circle on topics not usually discussed in their business conferences but vital to the business none the less. It is quite evident that not a few concerns have failed to sell their policies to their own foremen, and to their considerable loss.

Much of this is due to the fact that many chief executives are poor mixers and have no gift for imparting information to people of a different educational standard. It was also found that some foremen in industry actually think less about industrial relations and know less than some of their own workmen and the low educational caliber in economic matters of the foremen in most of our industries is remarkable, considering the effective part they might play in happily and justly reconciling not a few industrial differences at their inception.

This is not wholly or chiefly the fault of the foremen. They are usually selected largely for their technical proficiency in their own particular branch and then are forgotten by the management so far as the engineering of men is concerned. Even where they have been theoretically assented to, such things in practice are purely secondary matters with many employers. The number of plants with good policies and poor

practice in this respect is remarkable and has led to the organization of an effective service in this direction.

The generous treatment of foremen and the steady drawing-out of their capacities for leadership and for interpreting to workmen the policies and ideals of liberal-minded owners is the open secret of some of our most happy and contented businesses.

How the Workman Thinks

What do we find when the workman gets representation and comes down to details? What is the attitude of mind he discloses? These conferences have shown that some of his unrest vanishes readily before personal contact and vanishes for good, but we also find that he entertains fallacies and misconceptions about industry to which he clings tenaciously, and to which many of our foremen, who are frequently the sole source of enlightenment, are not qualified to make an adequate response.

Our foremen are too often during periods of industrial friction mere onlookers when they might be efficient leaders and molders of thought among the small groups which they supervise. Here are a few of the ideas which guide the average workman in judging his employer:

1.—He is all for the concrete, the direct, and the personal. He must be shown effectively how each proposal would affect his own industry, his own plant, and especially his own job.

2.—He frequently believes that all his aspirations and the claims of his trade on industry could easily be satisfied here and now out of present profits and with no more production.

3.—He often claims that "raising the sales price" will settle all his employer's difficulties, reward them both more liberally, and possibly reduce the effort demanded of them.

4.—When the obvious objection to this in its effect on all other trades and commodities is pointed out he says, "Well, let them pass the raise on also."

5.—Not a few workmen act on a conviction that it is a distinct advantage to employment and labor to restrict

output and that in doing so they are performing a moral duty to themselves and their trades.

6.—Finally, the average workman is little interested in community or national welfare. The public interest as a rule is too remote for him to be influenced by it. He often has the ideas that there is just so much work to go round, that profit is always a certainty, and these fallacies lie at the bottom of many stubborn and foolish quarrels in which they are never even mentioned.

What Our Foremen Lack

It may be said that these are commonplaces in the industrial world, but we wish to emphasize here that they are commonplaces to which several thousand foremen had no effective answer where it would have done most good.

It is our experience that large numbers of foremen ranging from 25 to 65 years of age can be sufficiently educated in a very short time by intensive processes to appreciate the industrial economics and human engineering of their job and to apply such teaching with enthusiasm in their daily routine.

Certain it is that no ideas which we fail to sell to our foremen can be permanently conveyed to our workmen, and while a wealth of endeavor is being expended on the moving soil of labor at present we should not overlook the permanency of a liberal investment in the education of our numerous minor executives.

Apart from technical proficiency, our extensive survey has revealed the same lack of training in the methods and principles of modern production as it did in handling men. Production methods are being increasingly elaborated by experts and converted into systems of operation but it is generally admitted by employers that unless these are related in the minds of the foremen to general industrial practice they awaken little interest.

Education for leadership in handling men and things has usually been concentrated on young men preparing for the higher positions, but the workman makes his contacts and

has most of his differences with the foreman and judges his employer accordingly.

For over a year intensive three-month courses have been given to several thousand foremen and executives in many plant groups. These have covered personal development, handling men, production principles and industrial economics; not in academic form but through four special channels, namely: Simple brief texts specially written for foremen; practical problems of leadership on which they correspond; lectures at intervals of two weeks to each group; and open discussions after lectures at which any topic is admissible.

The method is the Plattsburg one of short intensive training. It is found that any group of associated foremen can be effectively held together for that time with increasing interest. They have not the zest of adolescents for long-continued studies but they do respond to interesting brief courses.

The reactions of executives in widely differing industries in the discussions have been remarkable. Apparently no such opportunity has ever been afforded them though there is much about which they are curious. They practically talk on the same topics and many employers have testified that such an intellectual awakening has served many of the purposes of "a council of the whole" for the foremen of their plants.

A number of the classes have permanently organized on this basis. In the small plants it has been felt that such an enlightened, energized body of foremen in any concern might well form with the mass of the employes "a committee of the whole" on all industrial relations.

The High Cost of Living

Naturally among several thousand foremen, a class which did not profit like labor in recent years, the cost of living in one phase or another was a frequent topic. Here are the

conclusions arrived at in conference after careful discussion of facts and principles:

1.—Mankind can only have what it earns. The fifty-cent dollar in the American pay envelope is due partly to unavoidable currency and credit inflation but chiefly to the scarcity of goods and services. We must continue our war-thrift and diligence, in spite of the temptation to relax, until we have paid our debts.

2.—No juggling or jockeying by law, compromise or force with wages and hours of labor will bring the desired ease and comfort unless it is associated with greater effort or better directed effort. The ugly weapons of direct action and the general strike are a betrayal of representative government.

3.—The effects of proposed conscription of wealth cannot be confined to the rich. They spread everywhere and the poor are least able to bear them. Private enterprise can always produce more goods at less cost than socialized industry with its loose, extravagant control and absence of the economic urge. The way in which goods should be divided is always open to adjustment by common consent in a democracy but the goods we *must* have and every proposed new road to freedom must guarantee them. None of them does.

4.—The laws of economics are as rigid and immutable as the laws of physics. It would be just as easy to produce perpetual motion as to provide for a community which goes indifferently through the motions of production and then calls upon its government to divide something which it has not produced.

5.—The high cost of high living has not a little to do with the present unrest but there is no single cause for our troubles and no single remedy. "Profiteering" does not explain them, though it greatly aggravates public feeling; it calls for firm repression when practiced by either side in industry.

Conclusions

The relation of industry to the four partners concerned, namely labor, capital, brains and public interest, was studied

in each class of foremen with special reference to the conditions of harmony and productiveness. Here are the conclusions arrived at:

The workman will be contented as a rule if he obtains:

1.—Security of employment.
2.—A voice in fixing employment conditions.
3.—A fair share of the profits.
4.—Working hours yielding reasonable leisure.
5.—Prevention of profiteering.
6.—Suitable housing and welfare provision.
7.—Economic instruction.
8.—Opportunity to rise.

The contented workman will co-operate if there is:

1.—Elimination of all suspicion of his employer.
2.—Creation of confidence between him and the executives.
3.—Recognition of mutual interest in industry.
4.—Creation of machinery for facilitating acquaintance.
5.—Absence of all paternalism in industrial relations.

The contented and co-operative employe will be exceptionally efficient and productive if he is scientifically directed with special incentives, modern methods and appliances and if he ignores all labor restrictions on output and narrow trade demarcations.

Contentment in the workman is purely relative. In democratic industry and life a healthy discontent is the normal attitude of forward-looking people. Hence it is useless in our day for employers to aim at and plan for a quite docile organization of human units as some have done. American and alien alike should be encouraged in self-expression and given sufficient education about the nature of industry to use their self-determination intelligently.

In too many cases both workers and foremen are allowed to drift, so far as improving their intelligence is concerned. In connection with personal ambition the subject of profit sharing was extensively discussed and it was the general conclusion that no long-deferred benefit, or reward more dis-

tant than two weeks, has much influence upon a workman's output, though it might affect labor turnover and general conditions favorably.

Democracy is Altruistic

The moral effect of free discussion after study and lectures on these topics and many others was very marked. Many of the foremen were keenly anxious to know "where the boss stood" and nothing was lost by the utmost frankness on all sides in these private meetings. The "boss" did not always stand where he should and his education was admittedly improved by going to school once more "with the boys."

It was recognized that there are theories before us today for reconstructing society which plan for man solely as a gain-seeking animal. The theory that no man will make any sacrifice for liberty or for love but only for gain is held by the cynics in office, shop and street but it is poor business, for it is not true.

Democracy vigorously denies these assumptions. It banks with confidence on men as givers as well as getters and it knows that knowledge touched with emotion is always inventive, ingenious, persistent and victorious. Let us provide this knowledge liberally for the noncommissioned officers of industry—our foremen—and it will soon spread to the ranks.

Training Men for Foundry Work

By C. C. SCHOEN, Stamford, Conn.

During the stress of war, the training and dilution service of the United States department of labor was established for the purpose of recommending and developing efficient shop training methods in factories that would help to eliminate industrial inefficiency, overcome the shortage of labor and stimulate production of munitions.

It was discovered that many helpful features of organized training as applied to the production of war materials were equally applicable to peacetime industry. Therefore, immediately after the signing of the armistice this service was reorganized under the name of the United States training service to assist all industries, desiring assistance, to establish methods of training their workers within their shops. Among the industries that requested assistance of this service were machine, tool, textile, shoe, rubber, foundry and others.

With the number of available training experts limited, and a due date of June 30 set for the completion of this work, C. T. Clayton, director of the service, realized that only a fraction of those factories seeking help could be accommodated, and therefore delegated to different committees the task of outlining recommendations applicable to the particular industries most urgently requiring and desiring assistance.

The committee on foundry training confined its activities to the following schedule:

1. Confer with foundry organizations, clubs, owners and managers throughout the country, to ascertain their attitude and opinion.
2. Determine by means of a questionnaire—
   - (a) Character and extent of training being carried on at present.
   - (b) Reasons for present lack of training.
   - (c) Extent to which training is desired.

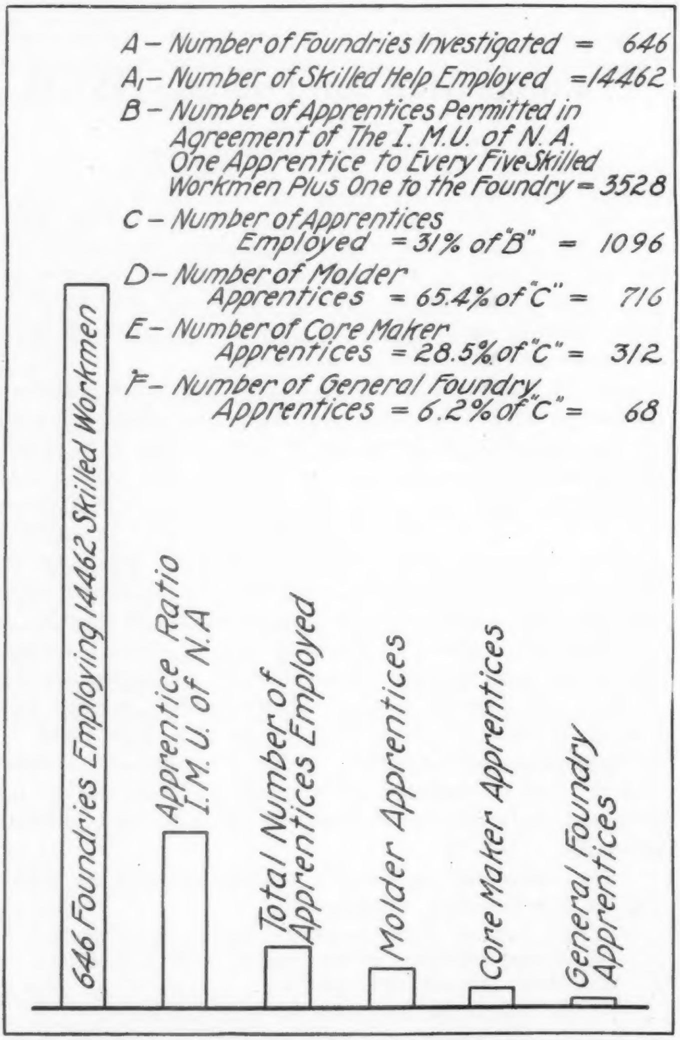


FIG. 1—RELATION OF NUMBER OF APPRENTICES TO NUMBER OF SKILLED WORKMEN

Chart showing relation of general foundry apprentices, molder apprentices and coremaker apprentices, to the number of apprentices permitted in agreement of the I. M. U. of N. A. and to the number of foundries in which the apprentices are employed and to the number of skilled help in these foundries.

3. Outline recommendations for the guidance of those instituting foundry training covering apprenticeship training, upgrading and training of foremen.

The foundry organizations that we conferred with were not only interested and enthusiastic, but appointed committees to co-operate with us. Aside from a small minority (less than 1 per cent) the owners and managers were very enthusiastic and pledged their support. About 1 per cent of the 646 foundries investigated have a definite program and less than 1 per cent give technical instruction. Of the 440 foundries replying on the upgrading question, 65 per cent are active in upgrading their help. The chart shown as Fig. 1 illustrates the extent to which training is carried on at present in foundries located in different parts of the country.

Considering the high turn-over prevalent in foundry apprenticeship, which in some cases has been given as high as 150 per cent, it is evident that the number completing their apprenticeship is very small. In general, the following reasons were given for the present lack of apprenticeship training:

1. Reluctance of young men to engage in foundry work.
2. Ease with which many young men with limited experience and knowledge can secure employment as journeymen.
3. The tendency of foundry employes to discourage apprentices.
4. Inability of foundry owners to master their training problems, etc.

Causes of the reluctance of young men to engage in foundry work have been given as low wages, unsanitary conditions, laborious work, monotonous routine, adverse influence of public schools, the four-year apprenticeship clause, lack of any sound, practical, or definite training program, and lack of proper incentives.

The effect of these causes on foundry apprenticeship, as illustrated by the chart, is the low percentage of apprentices

entering this work and, as you all know, the result that few of those who enter complete their apprenticeship.

In order to solve the wage problem, a few foundries make a practice of studying the cost of living in their town and granting apprentices' cost of living plus a percentage, ranging from 10 to 70 per cent. The highest percentage is paid to apprentices in their last year of apprenticeship.

A handicap, which many foundries have applied to their apprenticeship systems, is "inertia of habit." Systems with the

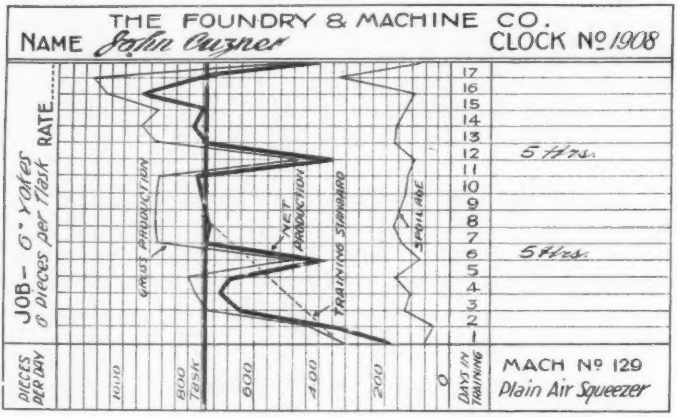


FIG. 2—TYPICAL RECORD CARD USED IN UPGRADING SYSTEMS

indentured agreements and rates of pay instituted 15 years ago, are still in use, although perhaps not operating.

Working toward the elimination of the effect of low wages, the four-year apprenticeship clause, the institution of proper incentives, etc., a plan is being developed whereby an apprentice's work, length of indentured period and compensation is dependent upon merit and accomplishment rather than time. This involves placing all apprentices on a two months' trial, and those accepted at the end of every six-month period are graded into classes as follows:

Class A, apprentices serving 825 hours per period
Class B, apprentices serving 962 hours per period.
Class C, apprentices serving 1100 hours per period.

The compensation is as follows:

Periods of entire course.......	1	2	3	4	5	6	7	8
Per cent of journeyman's pay..	33	36	39	43	47	52	58	66

To overcome the laborious and unsanitary conditions existing in many foundries, the adoption of sanitary, safety and labor-saving regulations, as recommended by the American Foundrymen's association and others is recommended. The following quotation from a letter received is indicative of what is being accomplished in this direction:

"* * * We are trying to gradually induce men to become foundry employes and to place the entire foundry on a higher plane, as we find that the average workman seems to feel that the foundry is hard work indeed and disagreeable place to work. To offset this, we have built what we believe to be the lightest, cleanest and best ventilated foundry in the United States; have installed lockers for the men's clothes, shower baths, drinking fountains, ample ventilation for summer and ample heating in the winter; which makes the foundry a comfortable and desirable place to work in."

To eliminate the condition of monotony, and to work toward a sound, practical and definite training program, the committee recommends a more general routing of apprentices into the different branches of foundry work and co-ordinating this practical experience with definite, practical technical instruction.

The machine and tool industry in a few cities has striven to acquaint the public school authorities with the importance of its trade by delegating a competent mechanic or engineer to lecture before the teachers' association on the character and importance of its work, and the opportunities existing for development. I am quite certain that a half-hour talk by a competent foundryman to a group of public school representatives would arouse in them a deep interest and respect for the foundrymen's trade.

The ease with which many young men, with limited knowledge and experience, can secure employment as journeymen is a direct result of lack of training. We have established a low standard in the foundry and apprentices apparently find a short term sufficient to measure up to the standard set.

The tendency of foundry employes to discourage apprentices must be overcome through education. Many employes sincerely and honestly discourage apprentices because they labor under unsanitary and unsafe conditions. There are other employes, however, who discourage apprentices because of selfish motives. Cases have been brought to light where journeymen and foremen advised apprentices that a study of technical subjects was nonessential and at the same time they secured for their private study copies of lessons given apprentices.

A number of foundrymen complain of journeymen discouraging apprentices in order to minimize the number of available molders.

The inability of foundry owners to master their training problems is chiefly due to lack of knowledge of the subject and the fact that they too often delegate this work to an overburdened foreman or a person incompetent to effectively operate the plan.

A clear conception of the purpose in view, an understanding of the methods and kind of authority necessary to achieve this purpose, ability to secure co-operation, centralization of training responsibility, a definite training program, practical instruction, workable standards, accurate records, and a square deal, are essential to success.

Existing conditions in the foundry industry necessitate a more general use of the upgrading system, which involves an intensive short-time training of the present labor and semiskilled help.

In order to meet this condition and at the same time pave the way for a broad training, the branches of training have been divided into units as follows in order to permit those desiring a broad training to gain experience and knowledge:

BRANCHES OF TRAINING FOR UPGRADING

Worker in Cleaning Department

Materials—Sand, abrasives, gases, acids, misc.

Equipment—Scratch brushes, chisels, hammers, files, etc.

Operations—Cleaning, finishing, assorting, repairing, mixing, applying.

ASSISTANT TO MELTER

Materials—Pig, scrap, flux, fuels, refractories.
Equipment—Shop and its construction.
Operations—Charging, firing, drawing, repairing.

POURING

Materials—Sands, clays, blackenings, misc.
Equipment—Shop and its construction.
Operations—Lining, baking, pouring, care of ladles.

COREMAKING

Materials—Sands, binders, re-enforcements, fuels.
Equipment—Shop and its construction, coremakers'.
Operations—Mixing sands, ramming, venting, re-enforcing, baking.

MACHINE MOLDING

Materials—Sands, facings, partings, patterns, misc.
Equipment—Machines and their construction.
Operations—Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing, pouring.

BENCH MOLDING

Materials—Sands, facings, partings, patterns, misc.
Equipment—Shop and its construction, molders'.
Operations—Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing, pouring.

SIDE FLOOR MOLDING

Materials—Sands, facings, partings, patterns, misc.
Equipment—Shop and its construction, molders'.
Operations—Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing, pouring.

CRANE FLOOR MOLDING

Materials—Sands, facings, partings, patterns, misc.
Equipment—Shop and its construction, molders'.
Operations—Tempering sands, ramming, re-enforcing, venting, finishing, setting cores, securing, pouring.

LOAM MOLDING

Materials—Sands, facings, partings, patterns, bricks, misc.
Equipment—Shop and its construction, rigging, molders'.
Operations—Laying bricks, sweeping, finishing, baking, assembling, securing, pouring basins.

ASSEMBLING

Materials—Sands, facings, chaplets, misc.
Equipment—Shop, assemblers'.
Operations—Lifting, setting cores, securing, pouring basins.

HEAT TREATING AND ANNEALING

Materials—Refractories, fuels, misc.
Equipment—Location, construction.
Operations—Charging, heating, drawing, repairing.

In instituting an upgrading system, consideration should be given to—

1. Centralization of training responsibility.
2. Definite training policy.
3. Location of training activities.
4. Competent instructor.
5. A detail study and analysis of each job in order to establish a standard time and a best method.
6. Issuance of standard practice instruction.
7. Record form, including standards of quality and quantity.
8. Follow-up system.

The record card, shown in Fig. 2, is representative of a type being developed at present.

In conclusion, the writer suggests that this organization take a definite stand in regard to the following:

1. Extent to which apprenticeship training is essential.
2. A standard of merit and accomplishment toward which training should be directed.
3. A standard form of indentured period.
4. Branches of training.
5. Length of indentured period.
6. Character of instruction.
7. Securing co-operation of public schools and assistance through the Smith-Hughes act.
8. Hours and time of instruction.
9. A standard record form.
10. Compensation.
11. Incentive.
12. Reward to graduates.
13. The establishment of a central clearing house to gather, develop and distribute literature and infor-

mation tending to develop knowledge and higher intelligence in foundry work.

The last suggestion has been submitted by Dr. Richard Moldenke, Pat Dwyer and others. Mr. Dwyer has submitted a suggestion in writing as follows:

"Instead of trying to get a competent local instructor for each plant, a feat which is neither practicable or possible, a central bureau should be established. A series of condensed papers could be prepared on every phase of standard foundry practice, each one by an acknowledged practical expert in his line. Copies of these papers would then be available for any man anywhere who wished to take advantage of them. The merits of this plan are that only the best methods would be in circulation; only those who are really in earnest would take advantage of them; and by having a competent representative body to sponsor and finance the scheme, the cost would not be excessive in any particular case."

In the final analysis, the success or failure of this work will depend upon the extent to which foundries will institute and promote training in their own shops.

There is a strong tendency among foundrymen to let the other fellow do the training and a few foundries have stated that they are not bothering with apprentices because they employ only first-class molders and prefer to hire them as best they can.

If every foundryman will appreciate the fact that his experienced and trained men will do most toward the progress of the foundry and then honestly and wisely endeavor to promote such training as is best applicable to his particular foundry, a start will be made, the results of which may far surpass our expectations.

Vocational Training for Foundry Occupations

By J. C. Wright, Washington, D. C.

Is the foundry industry one which lends itself to a program for vocational training—a program which permits of a permanent scheme of training and from which we may expect a reasonable return—or is the nature of the industry such that recruits for the trades are usually drawn from men who have been inducted from unskilled occupations and then have advanced from positions of helpers to those of journeymen?

Do young men seek entrance into the industry as a means of earning a living? If so, to what extent does a system of apprenticeship provide an adequate supply of skilled workers?

It is estimated that there are employed in the United States as molders, founders and casters around 200,000 persons. A survey of the city of Indianapolis, Indiana, shows 38 foundries with over 5000 employes under normal industrial conditions. Of these approximately 50 per cent are classified as skilled labor with 50 per cent as apprentices.

Old System Unsatisfactory

It is generally agreed that the old apprenticeship system will no longer meet the demands in the industry for skilled labor, nor do working conditions encourage young men to take up the molder's trade. The desire for higher wages and for "silk shirt" jobs where the work is not so heavy, causes many to seek other fields of employment. Hence, how to meet the need for molders is a problem of no little concern to the employers of today. While out of sheer necessity negro and foreign labor has been inducted into the industry, they cannot satisfy the demand for men who will enable the employer to keep up production and meet competition.

Foremen, and assistant foremen, are usually selected from the personnel of skilled labor and hence are almost entirely

dependent upon training by "absorption" in preparation for their responsibilities for production, for care and use of materials, for handling men and for the instruction of green workers.

It is to be expected that the foundry industry finds present conditions unsatisfactory. The supply of skilled labor is inadequate, many workmen are lacking in technical and mechanical skill, and many of the foremen they are forced to select are short in the technical information relating to the business and an ability to supervise production, handle men, manage their departments, and in a knowledge of plant practice.

A Field for Training

The foregoing statements are intended to point out the field for vocational training and to determine the aim of any training scheme which may be set up.

In formulating a vocational program for any trade or industry the responsibility rests with those in charge to determine the possibilities for training, the kind of schools, and the character of the subject-matter to be given in the course of instruction.

That there are few jobs for which effective training cannot be given is shown by a study of the job characteristics which may be used as a "measuring stick" to determine the need for vocational training. These characteristics have been set up by Mr. Charles R. Allen as:

1.—Anybody cannot learn to do the job. That is, in training, it is found that certain natural qualifications count, as quickness, neatness, a good eye, physical strength, weight, etc.

2.—The trade recognizes jobs of different degrees of difficulty in the same line, as, for example, in machine shop work or in making paper boxes there are recognized grades of jobs.

3.—There is a best way of doing the job.

4.—It is recognized that an appreciable period of time is required for a learner to reach maximum efficiency—in other words, a man cannot do the job as well the first time as he can after a period of practice.

There are but few jobs that do not meet these conditions. Is the job one involving the *training of workers for service* or

is it one which must be limited to the *improvement of those already in service?*

It is generally recognized among those engaged in vocational training that certain industries, due to the conditions surrounding the workers, are not such that the novice may be induced to accept training for service. Is this true of foundry occupations?

What kind of vocational schools or classes should be provided to meet the needs of foundry occupations? What is the nature of the subject-matter which should be included in courses intended to prepare new workers for service? What is the subject-matter which should be included in courses intended to improve the efficiency of those already employed in the foundry trades? What are the qualifications of teachers who will be able to "put over" the subject-matter selected for instructional purposes? Can the shop training be given in a school or should the courses be carried on in co-operation with an industrial plant?

Some of the Questions

These are some of the questions which will confront school officials charged with the responsibility of planning schools and classes to give vocational training to those who are preparing for employment in that occupation, or for the improvement of those who are already employed.

While foundry work has oftentimes been included in engineering and mechanical arts schools, it has seldom functioned as a part of vocational training. In most cases the foundry equipment has been installed in order to supplement courses in patternmaking and to equip the metal working shops in the institution to more readily obtain castings for their own use. The pupils enrolled in these courses have not, except in rare instances, engaged in employment in the industry. The courses of instruction have in most cases aimed to give the pupil an appreciation of working conditions in foundry occupations and a general knowledge of the processes involved. Even if the character of the instruction offered had been of such a nature as to adequately prepare the individual for efficient work as a molder, coremaker, or cupola tender, it would still be im-

possible for them to function as trade courses, since the pupils enrolled in these institutions are not selected from those who naturally seek employment in these occupations. In some instances evening schools have utilized these equipments for supplementary instruction given to those who have already sought employment in the occupation. This instruction has been much more effective.

As an indication that the industry is suffering from a lack of adequately trained men, inquiries are being received by the Federal Board for Vocational Education from employers, and organizations of employers, as to the possibilities of vocational training for their employes. These inquiries have to do not only with the improvement in efficiency of journeymen workers, but also with such trade extension instruction as will enable men, straw bosses, and assistant foremen to be promoted to positions of greater responsibility within the plant. One of these inquiries for definite information which would be of aid in the preparation of a plan states:

> We have nine plants, each plant being divided into a number of departments which have to do with the preparing of molds, handling of castings, cleaning and machining of same, the repair and upkeep of plant equipment, operation of unloading machinery and locomotives, etc., in the yard, making of patterns, etc. The question of foremen and heads of departments is one of considerable moment with us and while it has always been our scheme to make advancement from the ranks we feel that considerable special effort should be made to train certain of our men, straw bosses, assistant foremen, etc., so that they can become heads of departments. We wish to prepare a plan of education for this class of men, such a plan to be so arranged as to properly grade the men as to their various qualifications which in turn will result in advancement being given to the men who are best fitted for positions which we may have open from time to time.

While these inquiries indicate that industry has generally come to realize the need of vocational training to reduce the cost of production, to maintain a sufficient supply of trained men to meet the new conditions through increased scientific information and through the invention of labor saving machinery, some employers yet disregard the need of training and like Topsy the men "grow up." Others place the entire re-

sponsibility on foremen for production and such training as is necessary. Under these conditions workmen are apt to belittle the value of vocational training.

Cannot Rely on Instinct

Since the old apprenticeship system has fallen down, training for industrial occupations must be given in some way. People are not naturally prepared by instinct or environment for efficient work in modern industry. Training must therefore be secured by the individual previous to his or her employment or must be taken after the individual is on the job.

The first condition cannot be relied upon, since most people are unable to predetermine or choose their vocation long enough ahead to enable them to secure preparation for entrance into employment. It then falls upon the employer to provide some method for training his green men a scheme which will promote training by "intention" rather than by "absorption."

If the men are absorbed in the force under the present status of apprenticeship a long period will elapse before the novice reaches a fair degree of perfection. Many will quit and seek other fields of work where the work seems easier and the pay better. Quantity production will suffer, quality of workmanship will be affected and the cost of production, due to increased overhead expenses and loss of material, will further reduce the profit.

Suggested Program for Vocational Training

Any plan for vocational training must be concerned with either the preparation of new workers for advantageous entrance into an occupation, or the improvement of those already in service and should be based upon a careful study of the foundry occupations for the purpose of setting up:

1.—The aim of the courses of instruction to be given.

2.—A statement showing the type of schools in which instruction may most efficiently be given, the character of the equipmet required for the instructions, and the qualifications of teachers.

3.—First hand analysis of the working conditions affecting individuals employed in foundry trades treated

from the standpoint of what the worker is actually required to do and not from the position of "things as they ought to be."

4.—The selection and organization of instructional material, and

5.—Suggestive methods of instruction for the guidance of the teachers.

These steps are necessary for effective vocational training in any trade or industry.

The federal vocational education act has for its purpose the preparation of men and women for more efficient service in wage-earning pursuits. The provisions of the act make possible either the *preparation* of an individual for employment in a specific occupation, or the *improvement* of the trade and technical skill of those already employed.

The act was brought about for the purpose of stimulating states to promote vocational education in the fields of agriculture, trade, home economics and industry. Its specific aim is to make, through the stimulation of grants in aid to the states, more efficient wage earners. This may be done be preparing persons for new occupations, or by increasing the skill and knowledge of those who have already entered a profession. The act is exceedingly broad in its scope and makes provision both for those who are yet in attendance upon school in the form of all-day unit trade schools, and for those who have entered employment by evening and part-time schools or classes.

For the purpose of co-operating with the states in paying the salaries of teachers of vocational subjects and for the purpose of preparing teachers of vocational subjects, there has been appropriated a fund which, on a sliding scale, reaches the sum of $7,000,000 in the year 1926. Reimbursement is made to schools for work meeting the conditions set up in state plans approved by the Federal Board for Vocational Education.

The act provides for three kinds of trade and industrial schools, departments or classes:

1.—The evening school for instructions supplementary to the daily employment.

2.—The part-time school, which may be administered as trade preparatory, trade extension or a general continuation school.

3.—The all-day unit trade school.

In the organization of these schools consideration must be given to certain conditions of the vocational education act common to all state plans. These condtions may be briefly summarized as follows:

1.—All classes must be under public supervision and control.

2.—The controlling purpose of the instruction must be to fit for useful employment.

3.—The instruction must be of less than college grade.

4.—The minimum age for pupils in the evening school is 16 years and in the part-time and all-day school 14 years.

5.—Federal money can be used for reimbursement only for the salaries of teachers. All expenditures for equipment, supplies, and other forms of maintenance must be provided otherwise.

6.—Federal money is given only as reimbursement and must be matched by an equal amount of state or local funds used for the same purpose.

7.—All instruction in the evening school must be supplementary to the daily employment.

8.—Part-time schools must be organized for not less than 144 hours of instruction during the year.

9.—Unit trade schools must be organized for not less than 36 weeks, with not less than 30 hours instruction per week, one-half of which must be devoted to shop work on a useful and productive basis.

Experience in vocational education goes to show that trade preparatory classes are not as efficient as are those giving trade extension instruction. This is due to the fact that trade preparatory instruction is usually given to those between the ages of 14 and 18 who have not yet definitely selected the kind of employment for which they wish to be trained. This is especially true of the foundry industry and as a result the all-day unit trade school is without pupils who need preparation for service in these occupations. On the other hand, schools or classes which are of a trade extension character and which are

planned to give instruction for the improvement of those who have already entered service are much more successful. These schools include evening and part-time classes.

Evening and Part Time Schools

Evening schools should be organized in every community and should offer opportunities for the pupils to select subjects which will supplement their daily employment. Evening vocational schools are all of a trade extension character.

Part-time schools in their relation to the foundry industry may be either of a trade preparatory or trade extension type. To successfully administer either of these types it is necessary for co-operative agreements to be entered into between the public schools, the employer and employes. These schools are defined as classes which divide the working day or school time between instruction and practical work in the shop, factory, home, office, etc. The classes may be carried on at the school, in the shop, in class-rooms adjacent to the shop, in a building near the shop, or elsewhere. The instruction may be either manipulative in process, or related to process, or both. While the minimum amount of instruction per year must not be less than 144 hours, the course may be given once, twice, or more times each year, or may be operated continuously provided the courses are of such a nature that the individual may profit by the instruction taken in its proper sequence. The part-time school may then be organized in a number of different ways:

1.—*The Vestibule School.*—The industry may wish to concentrate the period of training into a single period giving full time each day to instruction. Where pupils are under definite, written contract for employment a vestibule school carried on for a period of 18 days for eight hours per day would meet the requirements of the federal act.

2.—*The Co-operative Week About Plan.*—This requires two pupils for one job, one of these being in school while the other is at work. The instruction during the week in school is largely of a supplementary character and closely related to the work of the pupil while on the job. During the week in employment the pupil is given an opportunity to apply

> the instruction received to the occupation, and through an individual known as a co-ordinator the instructor in the school is informed of the pupil's progress in the shop and steps are taken to see that the young worker is not exploited on a few operations but is given an opportunity to receive an all-around shop training. The co-operative plan in many respects is ideal. The pupil is brought into direct contact with actual working conditions in the plant. His practical experiences will be gained through the use of a wide range of commercial projects rather than through the use of models and a limited amount of practical work. This plan also lends itself more readily to the placement of pupils in industry than does the all-day school.

Where the plan proposed provides for an all-day school the plant and equipment should approach as near as possible the conditions which exist in an average foundry. Productive projects should be selected because of their commercial value. The project should be carefully analyzed into its several parts, each part in turn studied to seek out the process involved, all of these then being arranged in an effective instructional order.

Must Have Had Experience

Teachers of foundry work in the all-day school and co-ordinators of co-operative classes must have had actual foundry experience in the industry itself. Successful teachers should not only have a practical training at least three years beyond the apprenticeship period, but they should also be selected because of their familiarity with all phases of the occupation and their ability to explain the why of all processes and operations. In addition to these practical qualifications the teacher selected should present evidence of an ability to instruct others. He should be able to analyze foundry occupations and jobs and to organize his instruction material into an effective order before presenting the same to his pupils.

It is very difficult to estimate the probable length of time required in which green men can be prepared for efficient work in the foundry industry. Estimates vary all the way from six months to a year on the basis of an all-day or co-operative week about program. This statement is made on the assumption that the pupils selected have all reached a degree

of maturity which will enable them both physically and mentally to receive instruction.

While the use of automatic machinery has made less necessary the highly developed degree of hand-skill formerly required, its use has increased the need of mental alertness in order to keep up production and in order to protect fellow-workmen from injury. Modern business methods also make necessary an ability on the part of workmen to analyze jobs and operations in order to reduce the time element and to conserve physical energy.

As an illustration of the steps which must accompany any movement toward the organization of vocational training classes for foundry occupations a brief analysis of the principal occupations is submitted:

Analysis of Foundry Occupations

Principal occupations associated with foundry work.

1.—Molder

a.—Bench molder. } Iron Foundry.
b.—Floor molder }

c.—Brass molder (brass foundry).

d.—Molding machine operator.

2.—Core maker.

3.—Cupola charger.

4—Cupola tender.

5.—Chipper.

6.—Helper and laborer.

7.—Foremen Training.

Bench molder in iron foundry should be familiar with the putting up of molds for small castings of all kinds; should be expert in the use of snap flasks; simple molding with split patterns; molding from solid patterns, using green-sand match for duplicate work; molding from card of patterns; making duplicate pieces in large quantities by use of plaster or dry-sand matches with gated patterns; and should be expert in putting up molds from more complicated patterns, involving setting and venting of cores. Skill in pouring also necessary.

Floor molder in iron foundry should be expert in the putting up molds for large heavy castings in 2 or 3 part flasks, or flasks with more than three parts. Should be able to put up molds for heavy castings, involving parting, complicated core setting, vent-

ing, etc. Needs to exercise good judgment in ramming up mold, venting and locating risers and gates, and in pouring.

Brass molder should have essentially the same qualifications as the iron molder on bench work, but in addition, should have special knowledge of putting up molds for brass castings—especially with reference to proper ramming of mold, use of flour and other special facings.

Molding machine operator does not need to be a skilled molder. Most of the molding machines in use may be successfully operated by men possessing average intelligence who have had a little special training in operating the machine.

Coremaker.—The job of coremaker in an ordinary foundry is frequently filled by a boy. However, the making of cores requires considerable skill and some knowledge, especially if a variety of cores are to be made. The coremaker should have had sufficient experience in mixing oil sand to enable him to exercise good judgment in mixing up his sand so that it will not stick to the core boxes.

Also a coremaker needs to use judgment in placing wires in cores and in providing adequate vents. This is true even though wax wire is used for venting. Also some judgment developed by experience is necessary for a man to be able to bake cores properly. The work of pasting cores and applying core washes requires but little skill or knowledge.

Cupola Charger.—Cupola charger is a man who weighs up the charge of pig and scrap, coke and limestone, and sees that proper amounts are charged into the furnace at proper intervals. Often this work is performed by common laborers directed by the foundry foreman, in which case the charger does not have to understand why certain proportions of coke, iron, and limestone are used, nor anything more than in what order to shovel the various piles through the charging door.

Cupola Tender.—Cupola tender should be a man of experience in foundry work, and is in charge of the operation of the furnace. He decides when the iron is ready to tap, regulates the blast, and in small foundries does the tapping out and stopping in himself. Also has charge of snagging out the cupola; preparing sand bottom; and often in small foundries, snags out the ladles, etc. The cupola tender is responsible for seeing that all iron is tapped out before dropping the bottom at the end of a heat.

Chipper.—Chipper is a man who snags and cleans up the castings, frequently has charge of the tumbling barrel and pickling vat. Very often the work of chipper is performed by a skilled laborer.

Laborer and Helper.—Much of the work of a foundry is dirty, hot and disagreeable common labor, and requires only a small degree of intelligence and skill.

In small foundries where the sand is cut up by hand, some of this work is performed by the molders; in large foundries where the sand is cut up by machine, molders merely put up the molds and pour them, the dumping of molds, cutting up of sand, etc., being performed by common laborers.

The analysis of the foregoing occupations indicates that they are, with the exception of the laborer or helper, of a character for which vocational training can be given. On the basis of this analysis the following outlines for seven separate short unit courses are suggested:

COURSE 1.—*Molding Sand.*

This course should be taken by all men who have to do with the handling or use of molding sand.

Suggested topics for this course:

Characteristics of good molding sand as to strength, porosity, etc.

Suitability of coarse or fine sand for different classes of work.

Note: Sand which would be suitable for snap flask work is often entirely unsuitable for heavy floor molding.

Use of seacoal in molding sand.

Effect of too little or too much facing.

Cutting up and tempering the molding sand by hand and by machine.

Note: The effect of thorough cutting up upon the "strength" of the sand should be thoroughly explained. The sand which is properly tempered is very much stronger than the same sand not properly tempered.

COURSE 2.—*Trade terms, names of tools, etc.*

Some instruction should be given in the use of proper trade terms in connection with foundry work, for men who are not experienced. Such words as flask, cope, drag, cheek, gagger, chaplet, match board, bottom board, etc., should be discussed.

Also the exact names of all tools used about a foundry, such as: Rammers, trowels, lifters, draw spikes, gate cutter, etc., should be learned by the apprentice or helper.

COURSE 3.—*Bench Molding.*

For bench molders in iron foundries, and brass molders.

Suggested list of lessons:

Note: It is assumed that before taking this unit the man will have completed the instruction suggested on "molding sand."

1.—Putting up molds, using card of patterns. Practice in ramming, venting, etc.

2.—Putting up molds, using dry sand or plaster matches and gated patterns.

In connection with this work, instruction should be given in the proper use of parting sand; use of nails for sharp corners or small green sand cores, swabbing, etc.

3.—Simple molding with split pattern; gate cutting.

4.—Putting up several molds from solid pattern, using green sand match.

5.—Putting up more complicated molds—requiring instruction and practice in setting and venting cores; locating and cutting gates, etc.

COURSE 4.—*Floor Molding.*

It is assumed that before a man takes this course he shall have received instruction on "molding sand" suggested under Unit No. 1.

1.—Open sand molding.

2.—Putting up molds for large castings in two part flasks, particular attention to be given to proper ramming of sand, venting, location and number of gates and risers.

3.—Putting up molds for heavy castings, involving complicated parting, core setting, venting, etc.

4.—Drysand molding in iron flasks; use of facings; washes, etc.

COURSE 5.—*Coremaking.*

Suggested list of lessons for coremakers.

1.—Characteristics of good cores.

2.—Different binders used in making cores.

3.—Preparing and mixing sand for oil sand cores.

Note: The proper proportions of sand, oil and water are very important.

4.—Use of wires for strengthening cores.

5.—Proper venting of cores.

6.—Proper baking of cores.

7.—Making of cores requiring pasting.

8.—Pasting of cores and use of core washes.

9.—If core machines are used in the foundry, instruction should be given upon the operation of such machines.

COURSE 6.—*Cupola Furnaces.*

For cupola tenders and others who have to prepare and operate a cupola.

Suggested list of lessons:

1.—General explanation of the processes of melting iron in a cupola furnace.

2.—Cleaning up after a heat, including proper disposition of the dump, snagging out the cupola, daubing up the inside with clay, etc.

3.—Preparing cupola for heat.
  Putting in sand bottom.
  Note:—Proper mixture of old sand, clay water, etc., should be discussed.
  Mudding up and burning off spout, etc.
  Chipping out ladles and repairing the lining with mud, and burning out ladles.

4.—Charging a cupola.
  Proper amount of kindling to be put in; proper thickness of coke bed.
  Amount of initial charge of iron in proportion to the thickness of the coke bed.
  Proportions of pig and scrap iron, limestone and coke, in future charges for continued melting.
  Amount of limestone desirable for a flux.

5.—Operation of the cupola.
  Proper time to light cupola before putting on the blast.
  Regulation of the blast before the iron comes down and during the balance of the heat.
  Tapping out and stopping in.

6.—Devices for drawing off slag.
  Note: Usually not necessary in a small cupola.

7.—Use of aluminum and other materials in the ladle for special work.
  Note: The cupola tender should be familiar with the effects of aluminum, ferromanganese, etc., in the ladle for iron intended for particular classes of work.

8.—Regulation of the cupola for securing hot "sharp" iron for small work.
  Discussion of the suitability of sharp iron or dull iron should be made a part of this lesson.
  Note: In many foundries both gray and hard iron are at times melted during the same heat. Methods of charging the cupola where it is desired to run off both gray iron and hard iron during the same heat might form a subject for a special lesson.

9.—Precautions to be taken before dropping the bottom.

10.—Brass furnaces.

General explanation of the construction and operation of furnaces for melting brass and aluminum.

Proper location of crucible in the furnace.

Regulation of heat.

Prevention of excessive oxidation during melting.

Purpose of using various deoxidizers in the crucible before pouring, especially when large amounts of old material have been melted.

Note: The cause of porous and imperfect brass castings should be discussed. Sometimes this is the most annoying feature of brass foundry work.

COURSE 7.—*Trade Science.*

A certain amount of related instruction might well be given to molders and other foundrymen.

Suggested topics:

Some of the elementary principles of mechanics should be taught in a practical manner, in order to develop some basis for the exercise of judgment in handling heavy weights.

Practical lesson on center of gravity.

Practical lesson on stability.

It is most imperative for a molder to have a knowledge of fluid pressure, in order that he may understand the necessity for weighting down molds before pouring.

The following information is necessary, if a man is going to estimate with any degree of intelligence the upward pressure on the cope before the metal solidifies:

Ability to figure areas approximately.

General understanding of fluid pressure, so that it will not be necessary for a man to simply apply the rule for figuring this without understanding it.

A working knowledge of the rule for figuring the amount of the upward pressure on the cope before the metal solidifies.

Note: The rule for this is as follows: Total upward pressure (lbs.) equals the area of the entire upper surface (in sq. in.) x head (in in.) x the weight of 1 cu. in. of iron (approximately ¼ lb.).

12.—Lesson on specific gravity, weights of different materials, etc., per cu. in.

13.—Lesson on the expansion and contraction of materials under the influence of heat.

14.—Lesson on effects of heat—melting points of various substances, etc.

Nature of "burned metal."

The causes of the formation of gases when metal is poured into a mold, etc.

Use of acid for pickling castings; action of the acid in loosening the sand and scale, etc.

Safety in the use of grinding wheels for snagging castings and for other purposes. A man should have some notion of the limits of safety in regard to speed; and the danger of running wheels which are out of balance, or which are mounted in loose bearings. Also the danger of improperly adjusted rests should be made clear.

15.—*Practical Metallurgy.*

A practical study of the composition and physical properties and characteristics of cast iron.

Suggested topics:

Different varieties of pig iron—Northern and Southern Pig—Percentage of scrap which different kinds of pig will carry.

Proportioning of charges for the production of—

Heavy gray iron castings.
Light gray iron castings.
Hard iron.
Semisteel, etc.

Effect of sulphur, phosphorus, and other elements present in cast iron.

Effect of rapid cooling upon the hardness—use of chills—separation of graphitic carbon prevented by rapid cooling.

Compositions of brass—proportions of copper, zinc and tin for standard alloys—use of deoxidizers for the production of sound castings—phosphor bronze and other alloys.

Aluminum—Melting and casting of aluminum.

Production of sound aluminum castings. Use of aluminum to increase fluidity of iron for thin castings.

Alloys of aluminum.

Relation of Foundry Work to Patternmaking

All patternmakers should have had sufficient foundry experience to enable them to appreciate the problems which the molder has to solve in using patterns to produce perfect castings.

The patternmaker is the man who usually decides how a piece is to be cast; in other words, before starting in to build a pattern he has to figure out just how the piece will be molded. For example, to properly appreciate the importance of sufficient draft, the patternmaker should have had actual experience in drawing patterns from the sand. The construction of core boxes, loose pieces in core boxes and on patterns, etc., all calls for a background of foundry experience on the part of the patternmaker in order for him to work out all such and many other details so as to facilitate the work of the foundry.

The converse of the preceding statement is not necessarily important, *i. e.*, it is not essential for a first-class foundryman to have had experience as a patternmaker, although for a foundry foreman such experience is desirable.

Whenever the employers of large numbers of workmen wish to plan for the vocational training of their men arrangements should be made for co-operative agreement with the public schools in the community. Teaching, like other professions, is an art that is best accomplished by those who have made it their life business to instruct others.

In every state a state board for vocational education has provided for the promotion of trade and industrial education through the schools of the local community. The agents of the state board are specialists with practical industrial experience and are responsible for giving assistance to the local school officials in planning the types of schools, selecting teachers and equipment, and for seeing that the instruction is effective.

These two agencies, as well as the federal board are willing to co-operate with the representatives of the foundry industry in meeting the need for better trained men.

Personnel Problems in Modern Industry

By C. D. DYER JR., Philadelphia

In attacking any problem, it is well to know that which we are attempting to attain. In considering the solution of personnel problems, we are fortunate in knowing that the goal for which we are striving is definitely attainable. The solution lies in re-establishing mutual confidence.

That mutual confidence existed in the working relations between owners and employed in many cases, in that earlier day when each knew the other personally, is a matter of record. That the expansion and extension of industry has inserted a factor that makes the solution more difficult, will be conceded, but the fact remains that a revival of this former satisfactory relationship is possible.

In planning a solution, it is well to confine ourselves to terms that permit of definite analysis. For this reason, the "capital" and "labor" terms must be discarded in favor of the more practical conception of "employer" and "employed." Such a division taken as a basis of operation permits of a concentration not possible under the "capital" and "labor" alignment.

For illustration, assume three workmen employed for equal wages. The first may have diverted his savings to the purchase of securities in the concern by which he is employed, or in other interests, perhaps; the second may have acquired title to a home; while the habits or home demands of the third may have been such that no savings had been effected. The same would be found to be true if the resources of salaried executives were investigated. All men devoting brawn, skill or brain constructively whether as presidents, managers, skilled workmen, clerks or laborers, could be classed under the term "labor." They are engaged in producing wealth for the nation, from which all derive

benefit. Yet any of these may belong to or step into the so-called "capital" class overnight. The large number of Liberty Bond holders illustrates the possibilities of capital development on the part of many heretofore in the non-capital class.

In the employer class will be included those who interpret policies and those who plan and direct work. Under the term "employed" will be classified those who produce by means of their skill and labor, including, of course, all office help.

In that which follows, this definite line of demarcation should be kept in mind, as the solution is predicated on this arbitrary division.

The consummation of satisfactory relations requires hearty co-operation from all concerned. It is not enough that the employer should comprehend the viewpoint of the employed. The latter must with equal candor appreciate and accept the ideals and purposes of the former. No common interest can exist unless it is based upon mutual understanding and respect.

The three most important factors in securing and maintaining a proper industrial relationship are: First, the establishment of a definite policy, which is not easy; secondly, the proper interpretation of such a policy, which is even more difficult; and thirdly, the practical application of details in connection therewith, which is vital.

Establishing a Definite Policy

An adequate and sympathetic comprehension of mutual problems and mutual needs is a pre-requisite to policy formulation. To be of value, the policy must be formulated with the idea in mind of permanency, rather than expediency. It must provide sufficient elasticity to readily meet local or changing conditions. For the reason that it is essentially a proprietary program, dependent for success upon the co-operative spirit developed, it is only logical that the employed be given every opportunity of taking an active part in its formulation.

It is not only desirable, but essential, that all members of the employer class and a majority of the employed subscribe to its teachings. The four essentials to an effective establish-

ment of policy and the securing of the co-operation necessary to its successful functioning will be briefly described.

First—Opportunity must be presented to every member of industry, be he employer or employed, for advancement, financial remuneration, and development as a citizen and community member, according to his contribution to industry and to society at large. Many complications enter into the drafting of a just system of rewards. For this reason, before making a definite departure, an intensive study should be made of every element involved. This system in its final analysis should be based upon a dollar's worth of work. The fact that all have not the same perspective must receive the consideration which it requires. A system of rewards evolved on this basis and developed as the educational campaign that must go with it progresses, may be termed the "Merit System," but whatever its terminology, it is essential to mutual understanding.

Second—The fact that a return on investment must be forthcoming and that sufficient capital resources must be available for the development and extension of industry and the weathering of lean periods must be mutually recognized. This principle may be termed the proprietary factor of safety. It is, of course, directly interlinked with a just system of rewards. Mutual recognition of these inseparable factors is essential to mutual confidence.

Third—The policy must embrace teachings of the principles of Americanism. That the majority of employed must subscribe to a properly established policy, was previously mentioned.

It must be admitted that there are those associated with industry who either cannot, or will not, subscribe to anything constructive. It is fortunate that the latter type is in the minority. Were this not so, the future outlook of American industry would be indeed precarious. Whether this type will be taken care of by the employed depends upon the degree of success that is attained in creating an atmosphere where destructive measures arising out of unsound thinking and disloyalty will not be tolerated by the employed.

The other type, who by reason of lack of earlier ad-

vantages and education have not, in their present state, the mental capacity to follow other than the line of least resistance, irrespective of consequences, presents a problem requiring constructive and persevering effort that cannot be sidetracked. Coercion is not the remedy. The creation of the desire, through precept and example, is the initial requirement and furnishes the basis for a solution, through educational means of a more tangible nature later.

Fourth—Proper representation of employer and employed, in the formulation of the policy is of prime importance. Such a procedure will assist not only in determining a basis of common interest, but will aid materially in its interpretation and practical application.

Unless these four fundamentals are the controlling influences in the formulation of a policy, interpretation and practical application become makeshifts. Strong personalities may triumph temporarily, but a policy must be fundamentally sound to be of permanent value.

Proper Interpretation of Policy

Those who interpret policies have arbitrarily been termed "employers." It is important that an executive in charge of any organization be capable not only of securing material results, but of assuming leadership in developing morale.

Morale, let it be understood, cannot be confined to the employed. We must look to the employer for leadership. Size up any organization. If you find a high type of morale in the line, you may be sure of the source of inspiration. Only when the spirit of the square deal has been inculcated into every member of the employer class, until it is a very part of his every act toward those with whom he comes in contact, can it be expected to spread and develop loyalty among the employed.

Leadership involves salesmanship and enthusiasm can be made contagious. If that which is for sale is the best procurable, there will be customers, as a matter of course, provided the salesmen are properly organized and directed. One has but to study the contributing causes to the success of our

great war measures, particularly in industry, to appreciate this.

The principles underlying these measures were basicly sound, but the ideas had to be sold. When understanding was secured, unqualified co-operation followed. As a result, service became popular, and disloyalty in any form, unpopular. Neither employer nor employed countenanced it.

The same results, modified to peace time temperature, can be secured in industry, by constructive morale cultivation. The start, however, must be made among those of the employer class who come in direct contact with the employed or public. Any policy is judged by this contact. It measures the sincerity of the desire of employers for an improved relationship and it is deserving of most earnest consideration.

The practical medium for solving humanitarian problems should be under the direction of an executive occupying a status in an organization not inferior to that of the purchasing, production, or sales manager. When it is considered that the greatest asset in industry—the human element—is entrusted to him, the reason for this will be apparent. His department serves as a clearinghouse and should constructively influence the interpretation of policy according to conditions as it finds them in the field, and should further convey to the employed in its practical application of details the ideals and purposes of the management. The effectiveness of this medium depends to a large extent upon the honesty of purpose, tact, and executive and judicial ability of the industrial relations manager, and on his ability to develop these qualities in his associates.

Practical Application of Details

In considering the practical application of details it is obviously unpractical to even suggest the type of organization that should be developed to handle personnel problems in any particular organization. Local requirements must determine this. The consideration will therefore be limited to a description of functions.

The most important of these are employment, hospital and service, further functionized as follows:

1. Employment.—This function usually embraces re-

cruiting, hiring, adjustment of problems arising out of and in the course of employment, and discharging.

2. Hospital.—This function usually includes medical, surgical, dental and visiting nurse service and sanitation.

3. Service.—Under this function is usually included safety, compensation claims and adjustments, housing, wash-rooms and lockers, transportation, legal aid, loans, education, mutual benefit and other employes' insurance societies, employes' activities—religious, musical, social, athletic, etc.—Americanization training and assistance in securing citizenship papers, commissary, co-operative stores, publications, and general service to employes, and in some cases plant protection and fire departments.

Duties of the Employment Department

An employment department is essentially a sales agency. It must have access to an available supply of its commodity for the prompt filling of requisitions of varying specifications. In its transactions it has two customers. One is the man to whom it must sell the job. At this stage careful selection is essential, because the second customer, the requisitioner, must be presented with a product which will satisfy his requirements. If both are satisfied, all is well.

However, the employment department must operate upon the principle that its customers are always right. Goods falling short of specifications are returnable. It must stand behind its sales and be prepared to make all necessary adjustments. Misunderstandings may be the root of the dissatisfaction of both customers. Sometimes they can be straightened out; in other cases transfers or discharges are required.

The foregoing in a few words describes the function of a highly specialized work where personality and judgment, coupled with a highly specialized routine essential to proper application, play an important part.

Scope of Work of Hospital Department

The function of conserving the life, limbs, health and time of employes through adequate and prompt surgical, medical and dental service has been well established in industry for some time. Sanitation, or the elimination of un-

healthful conditions and habits is approaching that status.

The employer and employed have learned to appreciate how essential it is to their mutual interest that the human machine be kept efficient. This has been brought about by constant education and practical observation.

Activities of Service Department

The service activities are those through which the medium of common interest, man to man, can be practically established. It constitutes the morale builder, through the development of latent possibilities, which possibilities crave expression in employer and employed alike. It is the common meeting ground.

No other department can come so closely in contact with aspirations and needs of the employed and create constructively to the material benefit and added content of all concerned. This is especially true when the families of the employed are given opportunity to co-operate. This is a thing that cannot be purchased. It must be constructively enlisted. The stabilizing effect of a 24 hour a day attachment is self-evident and it brings with it a growing and more closely cemented loyalty.

Co-operation from the employer, essential in all departments, is vital in this department. Nowhere is whole-hearted interest so much appreciated, and nowhere will total indifference meet with such disastrous results.

Conclusion

This summary of general principles derived from a review of progress made in solving personnel problems is presented to you with the definite knowledge that mutual confidence between employer and employed does exist in certain organizations and with the firm conviction that it can be revived or developed, as the case may be, in others.

An internal problem is involved. Definiteness of policy combined with a broadminded interpretation in which the employer must assume leadership in the development of morale, and square and aboveboard dealings furnish the framework for constructive improvement.

Discussion On Industrial Relations

Mr. J. C. Wright.—I would like to ask the first speaker what his conclusions were as to labor turnover. He stated that the labor turnover was about 150 per cent. Do we conclude that this means that these men were going into other jobs, or were they going from plant to plant and remaining in foundry work?

Mr. C. C. Schoen.—Foundries keep no accurate records of the young men that are going in and out. They take young men into their shops and discover that in order to maintain their full quota of apprentices, which of course is not up to the full quota allowed, they have a turn-over of approximately 150 per cent.

In regard to the statement that competent instructors can be obtained, I have tried to distinguish between the men who do the training in the shop and the men who do the instructing. It has been found from experience that it is easier to get men to train apprentices on the job but rather hard to get men to take in a class of 15 or 20 apprentices and explain to them the theory of foundry work.

Mr. Wright.—Your second teacher I assume is not within the industry?

Mr. Schoen.—He should be taken from the industry but he cannot be found. Some factories endeavored to take some of their foremen and send them before their apprentices to lecture on the theory of foundry training but they could not do that because of the lack of understanding of theory on the part of the foremen.

Mr. Fisher.—I want to ask Mr. Wright whether the federal board for vocational training would be willing to help us conduct our vestibule school. We have instituted in our Detroit plants a foundry vestibule school and have adapted it as far as possible to the principles of training which Mr. Allen of the board has laid down in his book, "The Instructor, the Man and the Job."

Mr. Wright.—In answer to your question, the vocational education act provides for the federal board to make or cause to have made studies, investigations, and reports with particular reference to their use in aiding the states in the establishment of vocational schools or classes and in giving instruction in agriculture, trades and industries, commerce and commercial pursuits and home economics. Such studies, investigations, and reports shall include agriculture and agricultural processes and requirements upon agricultural workers; trades, industries, and apprenticeships, trade and industrial requirements upon industrial workers, and classification of industrial processes and pursuits; commerce and commercial pursuits and requirements upon commercial workers; home management, domestic science, and the study of related facts and principles; and problems of administration of vocational schools and of courses of study and instruction in vocational subjects.

If the school you have organized in Detroit is managed entirely by your concern; if the teachers are paid by the company no federal funds should be used for reimbursement since the school is not under public supervision and control. Only through advice and assistance in the way of publications could we co-operate.

Mr. Schoen.—The committee on foundry training consisted of Dr. Moldenke, Messrs. Steele, Dosey, Kennedy, Hoffman and others. Mr. Steele and Mr. Dosey and a number of other men have compiled a large number of excellent question sheets and it was deemed advisable to print a number of pamphlets covering these standard question sheets that every apprentice ought to know pertaining to his work. Now the question comes up as to who would bear the expense of these pamphlets.

Mr. Wright.—I regret that our printing fund has been budgetted for the year. We would be unable to co-operate in the matter of printing this year. It would be possible under certain conditions to get the material ready and put it into the budget for the next fiscal year, beginning July 1, 1920, but not before them.

The Chairman, Dr. C. B. Connelley.—I think that inasmuch as Mr. Schoen is training men for foundry work, if the committee is lacking funds, we might through the industrial committee of the association be able to have your report covered and distributed to the members of the association. We must have this report now and we want to produce it now because of the unrest and the conditions of American foundrymen. I venture to assert that the American Foundrymen's association will see to it, when the report is ready, that it is printed.

Mr. Porter.—I would like to ask Mr. Calder in choosing his executives, foremen, or higher up men, what weight he puts onto the different qualifications of the men?

Mr. Calder.—The subject of selecting personnel is entirely foreign to the paper which I gave. It is a very large subject, and the picking out of men by the manager or the higher executives is not delegated even to them but to people who have made a specialty of it. I don't think the average business executive of a plant can put himself in a position of doing much of that kind of work, but if your man is, say a foreman of an assembling department where machine operations don't count for a great deal, but where manual dexterity and carefulness on the part of the worker has a great deal to do with the quantity and quality, then the man you would put in charge of that group would have to be mentally in his habits of observation and thoroughness, concentration and judgment, a much better man than a man who simply was a foreman of a group of machine hands. The relative weights, of course, have to be figured out to some scale, but I don't think I could give any offhand opinion on the question as asked.

Mr. E. T. Miller.—May I ask whether you have had any experience in having groups of shops in your foremen's schools, or whether they were always confined to one shop?

Mr. Calder.—Yes, where the individual shops are small. We never have a class of less than 25, and they run up to 200. I would prefer that they shouldn't run over 100, but where in a city like Buffalo, Springfield, Hartford, or New Haven there are groups of foremen under 25 in numbers in various small

industrial plants, we have had public classes with anything from 70 to 150 men in them, and these groups of foremen met in the same way, but you can never get the same amount of interchange, and certainly you can't get the amount of private talk with the foremen in a public class as you would in a private class.

We have combination classes, but the greatest benefit of the course is derived where the group is not so large, where all know one another and where they have to work together and co-operate. This result is still obtainable where the public group is all from one industry, such as founding and all interested in the same material and human problems. They meet together on a common ground at these meetings with experienced men and talk about present day economic and industrial questions. We believe that education isn't pumping in; it is drawing out, and then in the discussion of the subject you can keep it going for half an hour or so or until the interest is exhausted.

THE CHAIRMAN, DR. C. B. CONNELLEY.—In the state of Pennsylvania we are handling many men in industrial work. I attended a conference not long ago where I said I believed that the narrowness of the workingman as well as of the manufacturers is due to the literature they read. I said to the workingmen that if they would get out of the rut of reading one kind of literature and would try to get a broader sense of the work in which they are engaged and get the views of different people in the country, that they would be much better informed. I was trying to get the equalization on a 50-50 basis between the manufacturing and laboring concerns.

An Association for Research on Alloys

By HARRISON E. HOWE, Washington, D. C.

The last four years have surely emphasized the dependence of material progress upon science and co-operative effort. We have even come to the point where something of benefit can be seen in the pooling of our technical practice and experience, while in some lines we have found that in revealing trade secrets we have been surprised how often we have gained more than we have given in the exchange. We have come to comprehend the truth of the prophecy made some years ago that the industrial progress or trade supremacy of a nation will be in proportion to the thoroughness with which science is utilized by the nation. This has been appreciated more fully by some countries than by others, but the war has thrown into bold relief those places where science has not been fostered as it should have been, and particularly those nations unable to organize and mobilize their scientific agencies. The rapidity with which scientific industrial research has been organized in the British empire, the United States, Japan and Italy, together with the results achieved, is one of our modern wonders, and, realizing that the same raw materials, methods and processes enter into the manufacture of both war and peace materials, the various countries have adopted the policy of establishing permanent research agencies. The extent to which this has been done is pointed out in National Research Council bulletin No. 1.

Great Britain Encourages Research

Great Britain has been active in officially encouraging research and has formed a government department of scientific and industrial research.

Industries or groups of related industries are being encouraged to form research associations and the British government stands prepared to furnish one-half the required funds. In all, nearly 30 such projects are on foot and of these at least three

have been licensed while six others are ready to apply for licenses. The subjects covered range from alloys to wool.

An extreme example is to be found in the association formed by the iron manufacturers who, in order to be free from the control which is inseparable from the use of public funds, have themselves provided the necessary money and, in addition to sharing mutually in all results of the research, propose to pool their experience and present information, even including trade secrets.

Progressive Work Necessary in United States

It scarcely seems necessary to further emphasize the necessity of similar progressive work being undertaken in the United States if we are to continue in the favorable position we have proverbially occupied in industry. With the possible exception of Germany, America has led in industrial research through the efforts of individual manufacturers, government departments, fellowships, research institutions and various commercial laboratories, but where one concern has been prepared to consistently and continuously support research, of a fundamental type, thousands have done nothing and have been content to draw upon sources of knowledge created by others.

We have many examples here in America of what research means to an industry. As Dr. C. E. Kenneth Mees has said, the incandescent lamp industry, which originated in the United States with the carbon lamp, would have certainly been lost to the United States when the tungsten filament was developed but for the research laboratory of the General Electric Co. That laboratory literally fought for the prize and held first place in the development of the first drawn tungsten wire filament. This has been followed by the inert-gas-filled incandescent lamp bulb, which, it should be noted, was really the result of research in pure science begun without immediate reference to its industrial application. A very considerable list of researches which have paid for themselves many times over could be compiled, and an English authority has pointed out that the investment made in the researches of the German dye firms has perhaps been the best investment the world has known.

We can pay tribute to the work of existing laboratories on alloys, both ferrous and nonferrous, and still say with emphasis that the problems are so fundamental that no one laboratory as now organized can profitably do all the necessary work. No doubt many of these laboratories can be fully utilized for phases of the problems in which they are expert, but there still remains so much to be done in the interest of so many manufacturers that it is believed a co-operative movement should be initiated. How can this be accomplished?

A few paragraphs above attention was called to the official encouragement given by the British government to the formation of such co-operative associations. In the United States the National Academy of Science was chartered in 1863, one of its functions being to investigate, examine, experiment and report upon any subject of science or art whenever called upon to do so by any government department, and from that time on the academy has discharged these duties with distinction. Very early in the great war the academy offered its services to co-ordinate the research facilities of the country, and upon being requested to do so by the President of the United States formed the National Research council in co-operation with the various national scientific and technical societies. The work done by this organization was of such merit that the President later requested the academy to perpetuate it. The chief objects of the council are to increase the amount of research being done in the country and to help train men capable of doing research, interpreting it and utilizing information so gained. It will be seen, therefore, that while enjoying the approval and support of the government, the National Research council is not a government body and differs in that respect from the English organization. The council proposes at this time to promote the organization of an association for the conduct of research upon alloys.

Plan Should Embrace Users of Alloys

In Great Britain research associations are formed primarily among manufacturers, but it has seemed to the National Research council that users of a material have much in common

and are less in competition than are manufacturers of such a material and it is believed, therefore, that under our conditions better headway can be made by forming an association composed primarily of users, but by no means excluding producers. It is believed also that work of this character should be done by the industries themselves. Individuals alone could proceed but slowly to discover all that science has to teach on these special subjects, but individuals banded together in such an association can make great progress. And, it is not a matter wholly for the government although certain phases of the question clearly come within the field of the bureau of standards, bureau of mines and the geological survey. The alloys industry is widely scattered and the men interested very numerous so that a new method must be sought. The industries have the most to gain; the industries should control the work; the industries should pay for the work; and it seems obvious that the best and most efficient method is to undertake the project in co-operation.

The laboratory of the Alloys Research association will establish a regular information service by means of which the individual firms will be kept abreast of the technical developments at home and abroad. To provide such service for itself any firm would have to employ at least the entire time of one man to read and translate the technical literature from all parts of the world. The laboratory will be prepared to supply a translated copy of any foreign article of special interest and will answer technical questions in as great detail as the scope of its own and allied organizations will permit. The laboratory will publish much of interest to other branches of science, and will be the best possible point of contact between the interests which it represents and other industries interested in the utilization of materials under study in the form in which they are sold.

What kind of problems would be undertaken? These may be considered under two general divisions: those relating to pure research, and the practical application of information so gained which we designate as industrial research. In the past it has been difficult to have some manufacturers realize that pure research, so often classified by them as academic or something in which the college professor only was interested, is

in reality something absolutely essential to them in the conduct of their manufacturing business. Some of the observations recorded in this manner have become of unexpected value later on, and such an extremely utilitarian device as the wireless telephone, if traced back, will be found to express in practical form the results of some half dozen or more purely academic experiments and mathematical calculations.

Function of Independent Laboratory

Indeed, it is because a works laboratory is more often a trouble department to which the organization turns for control and the solution of immediate manufacturing problems that the Research association must be formed, in order that we may obtain the facts upon which the laws governing the observed phenomena can be formulated for our guidance. When as a result of pure research we find out what takes place in an alloy when it undergoes changes to which it is subjected, then we shall be better able to find ways to so control these changes as to give us desired results to meet certain specifications. Our information on the properties of pure metals is really fragmentary, and in many cases the recorded data cannot be fully utilized because the complete history of the sample is not known. The phase rule diagram has been nearly completely worked out in the case of certain pairs of metals, but many important pairs have not been adequately studied. When we come to three component systems scarcely anything has been done, while the possible number of combinations that could be studied is very large indeed.

In determining quantitatively the relation between the physical properties, the chemical composition and the constitution of these various alloys, all the physical properties must be accurately measured, first in the case of the pure metals entering into these combinations, and then of the combinations themselves. Soon relationships will be established such that predictions can be made, and if we can be guided by the experience of those scientists who have used three component system diagrams to remove the mystery concerning the manufacture of optical glass and make it possible to produce glass of

distinct physical constants almost by mathematical computation, we ought to be able to choose constituents for some types of alloys to meet exacting requirements by similar methods. At present in many cases the properties of the constituent metals yield very little guidance in predicting the useful properties of an alloy and these may depend upon very close control of a number of dependent variables.

Perhaps it would be useful to recall some of the properties which should be determined in each instance in order that the magnitude of the work may be appreciated as well as the importance of the data which can be obtained in no other way. Density, hardness, fatigue, tensile strength, elongation, compressibility, elasticity, torsion, shear, bending and hydraulic determinations should be made. These are all mechanical tests and should be conducted at high temperatures ordinarily and also low temperatures. Then there is the melting point, the critical point, specific heat, heat of fusion, heat of vaporization, conductivity and expansion, and these must be determined over the same range of temperatures. Another group of tests has to do with electrical and magnetic properties and concerns capacity, resistance, susceptibility, permeability, radiation, absorption, emissivity, and thermo-electric properties. We must also consider solubility, susceptibility to attack by acids and alkalies, porosity of metals, effect of outside agencies such as pressure and magnetic field and the effect of impurities.

Special Problems Confront Research Workers

As to the practical side, it will perhaps be more striking to present our subject from specific rather than from general examples of application. If, as might conceivably be the case, it were possible to produce an alloy of aluminum that would have the necessary strength and at the same time a surface not so readily oxidized as is the case with present aluminum alloys, a great need would be met in the rubber tire industry where steel forms are now used in the manufacture of inner tubes. The aluminum is not only much lighter to handle but it gives a better surface and has other properties which make it desirable. Alloy steels have been a great factor in making inex-

pensive automobile parts, for in comparison with high-carbon steels or similar alloy steels having the required characteristics the machineability of vanadium steel, for example, is such that a part costing, say, $6.50 when finished would, because of the difference in labor, cost more than $13 if the high-carbon steel was used. This last mentioned steel requires grinding, and, while the difference in the cost of raw materials is extremely small, the labor item becomes the governing factor. In steels the word "alloy" appears to have become a panacea, and yet our knowledge is very limited and the tendency is to use an alloy steel because it is an alloy and not always because there is sufficient reliable data to justify its use.

One of the serious alloy problems is to find a method of increasing segregation in high-silicon irons so that they may become ideal from a machining standpoint without reducing their resistivity to the actions of acids and other reagents entering into the reactions of industrial chemistry.

Could Give Attention to Occluded Gases

There seems reason to believe that the occluded gases in metals may have a more serious effect than some of the impurities which we take great pains to eliminate. Only recently has accurate pyrometry been given proper attention, and the results obtained fully justify the continuation of that work in accordance with a well-thought-out and extensive program.

There is a multitude of problems yet unsolved in the art of die-casting, and many parts made by other processes might be better made by die-casting if we knew enough fundamental data concerning pure metals and their mixtures to enable us to compound the exact alloy for the particular purpose. Unsoundness, believed to be caused by entrapped air, is one of the great difficulties which might conceivably be overcome if our stock of knowledge were to be increased. Better compositions for crank shafts are needed as well as marked improvements in stream line steel or other tubing for aircraft production.

Recent experiments with one of the old and much discussed bronze formulae has shown that slight variations from the original empirical formula results, under proper conditions,

in a much better metal, and there are many similar examples that could be mentioned.

A study of steel deoxidizers and particularly an investigation of the use of the alkaline earth metals for that purpose could be undertaken with profit. Then there is the investigation of the deoxidizers for nonferrous alloys, their relative efficiency and function. A research could also be conducted along broad lines on the influence of the rare metals in nonferrous alloys, a field in which our information is very meager. Magnesium and related metals should be studied with reference to their use as deoxidizers for aluminum.

Use of Motion Picture Camera in Research

As an indication of the practical importance of working out new methods, we may cite the use of the motion picture camera using the microscope as a lens, by means of which the complete story of minute changes in structures of crystals has been recorded in the case of metal undergoing repeated stresses to the breaking point. The film indicates that failure takes place gradually, beginning the moment the metal is first put under stress, and in future we may be able to tell from the micro-photograph how much of its serviceable life a cable or other metallic member may have passed. With such apparatus at hand to determine how iron and steel deteriorate or weaken under stress, investigations may be instituted leading to heat treatment to prolong the life of certain alloys and make them less liable to fatigue or to gradual or sudden deterioration. This information would enable us to prolong the life of cables and ropes for elevators and bridges, and to apply this new knowledge in other directions to conserve both life and material.

There are a multiplicity of ways in which data compiled by the Research association could be applied in a practical and profitable manner. Costly metals would doubtless be replaced by less expensive ones equally adapted for special uses. Alloys would be developed for new applications and there would be miscellaneous improvements that are self-evident.

The laboratory of the Alloys Research association will find a tremendous amount of profitable work to do besides conduct-

ing research along specific lines. It could do a certain amount of testing as a check on and in co-operation with other laboratories; it could participate very effectively in work looking to the improvement of specifications; it could undertake, perhaps on a semicommercial scale, variations in present-day empirical formulae, which the average manufacturer fears to change. In many cases the laboratory could serve as a final court of arbitration should disputes arise, and for the account of any member of the association could undertake the solution of such problems as might not be of sufficient importance to benefit the entire association. This work could be done at cost. It is reasonable to expect that such a laboratory would become a final training school for men engaged in alloy work, and we might soon find that the better men throughout the industry had at some time or other been engaged in association work, either at the central laboratory or in some one of the co-operating laboratories.

This association will draw its members from, first, firms not now supporting a laboratory; second, firms having a laboratory but unable to devote the requisite time to fundamental research; third, firms similarly placed and working upon some phase of the problem but interested in conducting research in a broader way than the expense would justify in their own establishment; fourth, firms having but a secondary interest in alloys but nevertheless willing to contribute to the support of the association in order that a properly equipped and staffed laboratory may be at hand to which they may refer an occasional problem of importance to them; and finally, those firms which appreciate the importance of the work and join the association for advanced information not otherwise obtained.

Members of the association, whatever their part in the support of the laboratory, will find the total expense but a fraction of their employers' liability insurance and of their fire insurance. The returns are sure to be many times the expense, and one basic discovery alone would easily pay for the whole undertaking.

A Prime Cause of Inefficiency in Industrial Organizations

By Frank B. Gilbreth and L. M. Gilbreth, Montclair, N. J.

All trades, and particularly those connected with the foundry industry, are necessarily inefficient today. What are the causes?

There are demands for changes in wages, for better hours, and for increased production. Whether or not the demands are just, they must be answered in some way.

The answer lies in the increase of skill. In the paper presented to this association last year, the authors showed how skill could be discovered, measured, standardized, and transferred, and we brought as illustrations many films that showed in great detail the various stages of the process.

Last year the problem facing the foundry industry was largely one of maximum production. Some phases of the labor problem were not so pressing at that time, because of the patriotism inspired by war necessities. Today the labor problem stands in the foreground of attention. Increase of skill alone can answer the present demands.

It scarcely can be necessary to demonstrate that lack of skill is the prime cause for inefficiency in this country, and in fact, all countries. However, it may not yet be realized that lack of proper teaching is the underlying cause of this lack of skill.

Efficiency in teaching consists primarily of three things: *First,* determining the best way to do work; *second,* conveying in least time information of how to do work in the one best way; and *third,* presenting information so that it can be longest remembered.

The greatest obstacle to overcome in increasing the skill of a group of workers is that they have been taught the average methods by the average teacher. We are all ready to admit

this. We are not all, however, as ready to admit that the average teacher has had no opportunity to learn the best method, and is not equipped with modern devices for conveying information. The fault lies ultimately with the industry itself, in not having determined, captured and recorded the one best way, or at least the one best way extant, and put it at the disposal of the teachers.

The first step in this process must consist of recording the best present practice. However, this is not as simple a process as it seems. The records must include many things. Our researches have emphasized several laws, and an idea of these is essential if the existing information on this subject is to be secured, and this must be secured before the one best way can be deduced.

For example, it is a law in motion study efficiency that no two workers are found to use precisely the same motions, even in the same kind of work. This necessitates observing and recording the activities of several, and oftentimes of many workers performing the identical operation. Observant employes note this in their *own* work.

Demonstrators Have Three Sets of Motions

It is a law of motion study efficiency that every demonstrator has been found to have at least three sets of motions and that he does not and cannot use the same motions when he is working with the automaticity of skill at the usual speed that he uses when he demonstrates his method at the slower "demonstration-speed." This necessitates making records of usual and demonstration methods, and also at reduced and increased speeds, in order to note and record the variations.

It is a law of motion study efficiency that the synthesis of the best portions of the methods of two or more of the best workers will be found to present a method that is more efficient than the best method of any one worker. In the films shown, it will be noted that the methods of the workers vary exceedingly, and that some of the so-called "best workers" use some inefficient methods, such as not using the left hand properly.

It is a law of motion study efficiency that the worker

with the best record of output is not always found to be the best for demonstrating personally the one best way to the learner. His large output may be the result of his superior strenuosity and in spite of a poor method. Furthermore, knowledge of pedagogy does not necessarily accompany knowledge of one's job. It is necessary, therefore, to demonstrate the various methods to the best available teacher, and to record his methods of demonstrating the activities to a learner.

The best way is determined by making records of the usual and demonstration methods of the best workers available, by analyzing them, and combining the best elements of the methods into the one best method and by having this demonstrated by the best available teacher.

Having then secured this record, the actual teaching process consists of using the resulting film as a teacher, supplemented by the usual available teaching methods, oral, written, or whatever they may be. This record of the one best way having once been obtained is available forever. It teaches all newcomers the best way that has been. It will present the information in the best way that the best teacher has ever presented it. This in no way resembles the so-called commercial moving pictures. This information, available forever, is also *instantly* available. It can easily be brought to the foremen's meeting. It can be duplicated easily and cheaply and put at the disposal of manual training schools and corporation schools.

Compare this with the way trades are being taught. In 1910 it was said in Motion Study, "The present apprenticeship system is pitiful and criminal from the apprentice's standpoint, ridiculous from a modern system standpoint, and there is no word that describes its wastefulness from an economic standpoint." The great Amar has said the same obtains today in his country. "Our present methods of teaching must be overhauled and research laboratories inaugurated."

Devices for Visualizing Processes

Every day that passes serves to emphasize more strongly the correctness of these methods which are based upon teaching through the eye. Written instructions, charts, drawings, lantern

slides, stereographs and moving pictures serve as teaching devices for visualizing the process. Micromotion films have proved themselves particularly adapted to an efficient learning process. The activities to be studied may be repeated at will as often as is desired, according to the needs of the learner. An activity may be analyzed into its component parts, and even into the elements of the motion by taking a large number of pictures per second and thus slowing down the process when the film is exhibited at the usual rate of speed. Again, the activities may be analyzed by means of mechanical and other drawings made especially to illustrate one point at a time, with all extraneous subjects omitted. An activity may be summarized, by taking the pictures at a much slower rate of speed than is usual, and then exhibiting them at the usual speed.

Attention may be secured and interest held by "exaggeration" as to scale and by means of the surprise by sudden changes of scale and also by the use of the "close-up." Emphasis may be secured by means of moving cartoons to illustrate a particular point. The sequence of operations may be made impressive by running certain portions and in certain cases, all of the film, backward. Explanations can be included by means of captions inserted in the picture, which may consist of "reasons" and "directions."

Similarity to other activities can be demonstrated by including bits of film showing similar activities in other lines of work. These are only a few of the benefits of the film as a teaching device.

Motion Study of Coremaking

It may seem a long cry to an increased production of cores from a motion picture film of coremaking, but some day it will be realized that through the discovery and adoption of "the one best way to do the work," and through that alone can come the increased production, increased wages and increased health and happiness of workers that are essential.

As for the practicability of the method, in order to cooperate in work for the blinded, we have, during the past year,

through the co-operation of L. W. Wallace, A. B. Segur and others of the Red Cross Institute of the Blind, made records of coremaking. These films show that this process applied to one small division of the work of an industry will standardize the activity involved, make possible its division into parts requiring different capabilities, add a new group of available workers, supply a new element of interest, result in increased production, make possible the payment of higher wages, eliminate unnecessary fatigue, exemplify efficient motions, and do away with a prime cause of inefficiency by supplying an adequate means of discovering, standardizing and transferring skill.

Expense is Not Prohibitive

It has sometimes been thought that the expense of this method is so great that it could be afforded only by groups of employers or by an association, but this is not true. It is not expected that this method is ever to be carried so far as to approach a diminishing return, and when it is realized that the difference between usual and customary output and the outputs resulting from this method of research and teaching is usually more than three to one and sometimes five to one, the importance of recording the one best method of doing work and teaching it can be realized.

Comparison of Costs of Electric and Open-Hearth Furnace Practice

By E. H. Ballard, West Lynn, Mass.

The advance made during the past few years in practically all branches of manufacturing has been reflected, in a marked degree, in the steel casting industry. Foundry engineers have demonstrated by many remarkable examples, the advance in the foundry art. Without question the necessities of war have done more to stimulate the steel casting industry than any other single cause.

It is a matter of general information that prior to the war many modern foundries were built with the objectionable features of the old time foundry removed, having in mind only such features as spell efficiency and lower the cost of production. Electric steel melting furnaces were installed in a number of foundries. The success following their installation is well known to most foundrymen. Without the electric furnace it is doubtful if the steel casting industry would have been able to contribute such a variety of necessary articles needed in the execution of the war, particularly gun castings, truck wheels and parts, ship castings, anchor chains, etc., all of which presented many difficulties which were overcome by the persistent efforts of the foundrymen called upon to produce them.

The increased number of electric furnaces installed during 1917 and 1918 and their successful operation interested the Lynn works of the General Electric Co. to the extent of inducing the authorities in charge to make a thorough investigation. It is true that a 5-ton electric furnace has been operated successfully for some years at the Schenectady plant and it may appear strange that Lynn foundrymen have been so backward in not making this investigation earlier. The truth of the matter is that for 26 years at the Lynn works the acid open-hearth furnaces have been able to pro-

duce practically all classes of castings required, varying from 1 pound to 30 tons, and meeting all specifications physically and chemically.

In order to maintain production from the open-hearth furnaces at reasonable cost, and to keep pace with the labor shortage, many changes have been made by rearranging the entire open-hearth department, installing traveling cranes with lifting magnets, and a mechanically operated charging machine.

Fuel oil economies have been carefully studied, so that under favorable conditions it has been possible to produce a ton of steel with 37 gallons of oil per net ton of melt. These factors have made it possible to produce molten metal in the ladle much cheaper than could be done electrically.

With radical changes in design of much of the product, the engineering department began calling for work difficult, if not impossible, to produce in the open-hearth furnace, particularly where a small quantity of alloy or special carbon steel was required. Producing small heats in a 20-ton open-hearth furnace is not economical; neither is it good business to make a full sized heat requiring special mixes, using only a small portion for the particular work desired, and pouring the balance into regular commercial work.

From the investigation made of the electric furnace, it seemed that this process would meet the particular requirements. The latter part of 1918 the installation of a 6-ton basic lined heroult furnace was completed. Regular production was commenced in December, 1918, with an entirely inexperienced organization. The furnace was operated for four months, day shift only, enabling us to secure actual cost data.

The open-hearth department, having been organized for the past 26 years, and made up of many men who had been with the foundry for practically the entire period, it goes without saying that to contrast the operating expense of the old organization of the open-hearth with the new organization of the electric furnace, we should not be too severe in our criticism when analyzing operating costs.

The writer believes, however, foundrymen will agree,

Per cent	Metal charged	Price	Per	Cost per N.T.
1.00	Pig Iron	51.00	G. T.	0.46
1.00	....	51.00	G. T.	0.46
	Scrap			
20.13	Foundry Accumulations	18.00	G. T.	
1.64	Castings from Scrap Dept..........	18.00	G. T.	3.50
15.63	Scrap 0.06 Unguaranteed...........	21.25	G. T.	2.97
0.49	Nickel Turnings	21.50	G. T.	0.09
58.71	Steel Turnings	8.50	G. T.	4.45
0.55	Nickel Accumulations	21.50	G. T.	0.11
0.60	Iron Borings	12.00	G. T.	0.06
97.75		12.80		11.18
	Special Metals			
0.54	Ferrosilicon	155.00	G. T.	0.74
0.37	Ferromanganese	225.00	G. T.	0.74
0.09	Wash Metal	71.20	G. T.	0.06
0.07	Aluminum Titanium	166.90	G. T.	0.12
0.04	Nickel	0.50	Lb.	0.38
0.06	Copper	20.16	100 lbs.	0.23
0.08	Iron Ore	9.16	G. T.	0.01
1.25	....	204.38	G. T.	2.28
100.00	Total Metal Charged.................	15.59	G. T.	13.92
	Molten Metal Cost			
	Cost of Metals..................			13.92
	Direct Labor			2.00
	Items of Expense—(per detail below)			21.58
100.00	Total Cost of Melt..................			37.50
8.00	Shrinkage			
92.00	Cost of Metal in Ladle.............			40.52
30.90	Credit—Scrap Produced	16.16	N. T.	
61.10	Good Castings Produced			53.06
	Summary of Expense			
	Electrodes (30 lbs. per Net Ton Melt)	0.08	Lb.	2.52
	Current	0.0125	KW.	9.05
	Oil-Ladle	0.079	Gal.	0.26
	Water			0.24
	Slagging Material—(Lime, Fluor-, spar, Syndolag, Carbon, Coke)...			1.79
	Furnace bottom sand	4.47	N. T.	0.01
	Ladle Repairs			0.43
	Furnace Repairs			1.27
	Royalty (Ave. per net ton output) $0.446			0.27
	Depreciation 10 per cent...........			1.14
	Expense—Labor			1.30
	Expense—All other			3.30
	Total Melting Expense			21.58

Heats poured, 131.
Average weight per heat, 13,918 pounds.
Metal melter per 100 kilowatts, 275 pounds.
Kilowatt-hours per net ton melted, 720 kilowatt.

Seventeen weeks actual operation, January to April, 1919, inclusive.

OPEN-HEARTH FURNACE

Per cent	Metal Charged	Price	Per	Cost per N.T.
10.82	Pig Iron Delaware	51.00	G. T.	3.45
	Robersonia	50.00	G. T.	1.45
10.82		50.70	G. T.	4.90
	Scrap			
40.40	Foundry Accumulations	18.00	G. T.)	
0.87	Foundry Scrap Casting	18.00	G. T.)	8.05
8.80	Castings from Scrap Dept	18.00	G. T.)	
2.45	Scrap 0.06 Unguaranteed	21.25	G. T.	0.46
18.08	Scrap 0.04 Guaranteed	24.78	G. T.	4.00
16.40	Bundled Sheet	12.05	G. T.	1.77
87.00		18.37	G. T.	14.28
	Special Metals			
0.52	Ferrosilicon	155.00	G. T.	0.68
1.29	Ferromanganese	225.00	G. T.	2.60
0.01	Wash Metal	71.20	G. T.	0.01
0.11	Aluminum Titanium	166.90	G. T.	0.18
	Silico Manganese	270.00	G. T.	0.01
	Aluminum	0.175	Lb.	
0.21	Iron Ore	9.16	G. T.	0.02
0.04	Spiegeleisen	60.00	G. T.	0.02
2.18		180.91	G. T.	3.52
100.00	Total Metal Charged	25.42	G. T.	22.70
	Molten Metal Cost			
	Cost of Metals			22.70
	Direct Labor			0.83
	Items of expense (per Detail below)			9.95
100.00	Total Cost of melt			33.48
8.00	Shrinkage			
92.00	Cost of Metal in Ladle			36.38
35.66	Credit—Scrap Produced	16.05	N. T.	16.05
56.34	Good Casting Produced			49.24
	Summary of Expense			
	Fuel Oil—O. H. Fur., Gallons	0.079		3.65
	Furnace Bottom Sand	4.47	N. T.	0.25
	Ladle Repairs			0.22
	Furnace Repairs (Actual—Labor and Material)			0.77
	Depreciation (10 per cent on original cost)			0.98
	Expense Labor			1.46
	Expense, All Other			2.62
	Total Melting Expense			9.95

Heats poured, 162.
Average weight per heat, 37,358 pounds.
Metal melted per 100 gallons oil, 4500 pounds.
Fuel oil per net ton melted, 44.4.

from the figures which follow, that the costs of the electric furnace are comparable when it is considered that the product of the electric furnace is superior and is fully meeting chemical and physical requirements. It will be noted that in analyzing costs the kilowatt consumption per net ton in the ladle is 720. This apparent high consumption is due to the fact that 60 per cent of all heats are double slagged. A very conservative estimate for single slag heats, operating according to our practice, is 650 kilowatts. The power charge of $1.25 per 100 kilowatts is abnormally high. A material saving in labor costs could be effected by employing a mechanical charging device which would reduce the charging time.

During the 4-month period, used as a basis for cost comparison, both the electric and open-hearth furnaces were operating on short time, due to lack of business. Also it should be remembered that we are comparing figures of a 6-ton basic electric furnace against a 20-ton open-hearth acid furnace. There are a number of items entering into the cost of both processes which would be somewhat modified providing both were run at full capacity. It is indeed uncertain and unreliable to make up figures in any other way than on the basis of actual running cost. The figures are presented on this basis in hopes they will serve as a means of comparison and be of material benefit to foundrymen.

In analyzing costs, the metal charge of $11.18 per net ton for the electric furnace should be noted. Substituting steel turnings at $8.50, gross ton, in place of 0.06 scrap which was used, would reduce the metal charge by $1.66 per net ton of melt. This mixture is practical and would have been used in our case if turnings had been available at the time.

Analyzing Comparative Costs

The cost of special metals for the electric furnace was $2.28 per net ton. For actual comparison we should eliminate the charge for nickel and copper, replacing 1749 pounds with ordinary scrap. This would reduce the special metal charge 49c per net ton.

In analyzing the expense items of the electric furnace,

a current charge of $1 instead of $1.25 per 100 kilowatts should be assumed. This item would be reduced $1.80 per net ton of melt. The fuel oil charge for the open hearth is $7.90 per 100 gallons. A very conservative price for oil would be $5 per 100 gallons. The fuel oil consumption, as shown in cost, is 44.4 gallons per net ton of melt. This is high due to furnace operating on short time. If we assume a consumption of 37 gallons per net ton of melt at 5c per gallon, according to our practice, the fuel oil cost per net ton of melt would be reduced $1.85. It should be stated that these figures are not estimates but are actual tank measurements, checked by accurate oil meters, and include the heating of ladle, and week end heating up of furnace.

With the open-hearth furnace operating full time a number of cost items would be materially reduced, as follows:

Direct labor	0.24	per net ton
Expense labor	0.50	per net ton
General expense	0.75	per net ton
Depreciation	0.25	per net ton
Repairs	0.24	per net ton
	1.98	

Summary of Costs

The writer believes that foundrymen will agree that the exceptions above noted are not in the least exaggerated, and are shown for the purpose of presenting the best comparison that the figures will permit, assuming both furnaces are operating under normal and reasonably full time conditions. With the reductions, as above noted, a summary of costs is as follows:

	Electric furnace	Open-H'th fur.
Total metal cost	9.52 net ton	14.28 net ton
Special metals	1.79 net ton	3.52 net ton
Expense items	21.58 net ton	6.60 net ton
Molten metal cost in ladle	36.57 net ton	32.55 net ton

We feel that we were fortunate in having had the opportunity of making observations and comparisons between the two processes covering a period of seven months. We have concluded that, for the special requirements to be met, electric furnace steel is superior to the open-hearth product from a quality viewpoint, and consider the cost comparable with open-hearth costs and not prohibitive.

Conclusions

The following are some of the reasons on which the conclusions are based:

1. Freedom from serious checks in castings, due to absence of oxides, and the lower phosphorus and sulphur content.

2. High temperature easily attained, adapting it for light section casting.

3. Carbon and alloy ingots up to 13½ inches (which we have produced) show marked superiority over ordinary open-hearth product, due to more complete deoxidation of the steel, producing a sounder ingot with less pipe and freedom from segregation, with superior forging and heat-treating qualities.

4. Possibility of taking small portions of heat, producing different compositions from the same heat.

5. Permits of intermittent running with less damage to furnace than to the open hearth.

6. Flexibility of working in conjunction with open hearth, permitting the casting of pieces beyond the capacity of one furnace.

7. Low cost of furnace charge, practice permitting a charge of 75 per cent steel turnings with 25 per cent foundry scrap, an advantageous low-priced mixture.

8. Low cost of producing a high grade steel for both castings and ingots.

9. Scrap produced by electric furnace used in open hearth as 0.04 material, improving finished product of open hearth at a saving in price of 0.04 material.

Discussion—Comparison of Costs

Mr. P. Bendixen.—I would like to ask Mr. Ballard what he would substitute for turnings if turnings were not available?

Mr. E. H. Ballard.—The cheapest boiler plate or forge scrap that can be produced or purchased; what we would call 0.06 or unguaranteed material in proper shape. But ordinarily our experience has been that if we hadn't sold our turnings way ahead of the anticipated requirements we would have had ample. I think the majority of people balance those conditions themselves, and their output would be governed by the cheap low priced scrap that they were producing themselves, but 0.06 or the cheapest scrap would be substituted.

Mr. W. E. Moore.—What Mr. Ballard has said regarding the suitability of electric steel for steel foundry use is entirely true. His remarks would, I believe, have been even more favorable to the electric foundry steel, if he had been running an acid instead of a basic electric furnace. While the basic electric furnace is more simple to operate and quicker to put into production than an open-hearth furnace, the acid electric furnace is still more simple to operate and many foundrymen who have had both basic and acid experience maintain that acid electric steel makes sounder castings, on which there is less cost for cleaning and welding.

In one case under my observation they had been making basic steel, keeping four welders busy in the cleaning room, and when they changed to acid electric steel, one welder was all that was necessary to keep up production on the same character and tonnage of castings.

The acid electric furnace shows somewhat lower power and electrode consumption and the refractory life is at least double as compared to basic operation. The acid technique is more simple and more rapid. With the modern rapid type acid electric furnace under favorable conditions, it is possible to get 14 or more heats per day. The heats come so rapidly

and the furnace is so efficient that the product is actually cheaper than open-hearth steel and very much cheaper than converter steel.

In one case where a rapid type electric foundry furnace of 3 tons replaced two 2-ton converters, the cost of the steel at the spout was reduced $35 per ton, even though the power cost was approximately 1½c per kilowatt-hour; the converter practice, too, had been well standardized after several years use and the electric furnace was then new and further improvements were expected.

Mr. Ballard.—The quality of steel which we were called upon to produce to our mind called for the lowest possible phosphorus and sulphur content. We naturally turned to the basic for that reason. I am not defending the basic process over the acid; we merely exercised our judgment in the matter of furnace lining, results of which we feel have justified our action.

A Member.—This matter of freedom from serious cracks is rather interesting and I do not suppose the checks are absolutely absent in the case of electric steel, but I was wondering about what the reduction would be compared with the open hearth.

Mr. Ballard.—This question was recently answered some few days ago by the writer, stating that to my mind metal plays a secondary part in the question of checks, assuming that the processes of acid open hearth, and electric steel making are properly performed. Generally speaking open-hearth steel is made under ordinary supervising conditions. With the electric furnace keener supervision and closer attention must be paid to the furnace operation, resulting in a somewhat improved product. To my mind the question of checks is more often one of mold troubles rather than of metal. I firmly believe that with the same close attention paid to operation of the open hearth that is now given the electric furnace, there would be little difference between the product of the two furnaces. Without question the temperature is under better control in the electric than in the open hearth, together with the fact that the steel is much freer from oxides.

Electric Versus Converter Steel

By John H. Hall and G. R. Hanks

At our High Bridge plant we have a 3-ton heroult electric furnace and a 3-ton bottom-blown bessemer converter working side by side. The electric furnace is operated on a basic bottom, which enables us to turn out steel very low in sulphur and phosphorus.

During the war we had orders for castings for the army and navy, and in order to use our converter for castings of this class we installed the Stoughton oil-burning process on our cupolas, by which we were enabled to turn out steel sufficiently low in sulphur to meet the government's specifications and in many cases to get sulphur considerably below 0.06 per cent.

We had always been able to meet the tensile tests for Classes 1, 2 and 3 army and navy A, B, C and D steel with converter metal and after we had the oil on the cupolas working successfully we undertook to turn out army and navy work with converter steel as well as with electric steel.

We had not gone very far with the more intricate castings before we were faced with the fact that the converter steel, even when the sulphur was around 0.05 per cent, was much more subject to hot cracks and tears than the electric steel and apparently it was not always true that the lower sulphur heats were any better in this respect than the high sulphur heats.

Kept a Record

In order to throw some light on this question we kept very careful records on one of the cradle-band castings for 240-millimeter howitzer. These castings were of Class 3 steel but in our practice we poured them with steel running from 0.25 to 0.35 per cent carbon and secured the desired high tensile strength by heat treatment. The table on

page 223 gives the analyses of a number of converter and electric heats from which castings of this pattern were poured and shows clearly the large proportion of cracked and torn castings on the converter steel. An examination of this table will show that in the converter heats on which no castings were lost the sulphur was as high or higher than on the heats on which castings were rejected for hot cracks. It will also be noted that at least one of the electric furnace heats (No. E491) is not very low in sulphur and on this heat we lost no castings. In fact electric heat No. E491 with 0.032 per cent sulphur is directly comparable with converter heat No. 68528 with 0.038 per cent sulphur, on which a casting cracked.

Resorted to Stunts

In our efforts to overcome the hot tears in the foundry we used all of the "stunts" that could be worked out with any reasonable theory behind them and some of them were as follows: The castings were made in both green and dry sand; they were taken out of the molds hot; were allowed to cool over night, etc. Some of these same molds were relieved to allow free shrinkage by destroying the sand grip, while other molds merely had the cope lifted and were allowed to remain until they were cold. During our experiments as above enumerated we determined that the castings poured from electric steel could be handled in most any manner that time and equipment would allow and our results produced very few rejections, whereas with castings poured from converter steel we were unable to produce any large proportion of good castings regardless of the manner in which they were cared for.

Somewhat later we undertook the manufacture of rudder stocks and stern frames for merchant ships, and our experience on these castings was even more illuminating than on the smaller castings for ordnance work. The reason for this, of course, was that the castings were so long as to give a very great total shrinkage amounting to 5 inches. Our first really conclusive test on these castings came when we were

obliged to pour a rudder stock from two heats of converter steel which analyzed as follows: Carbon, 0.29 and 0.31 per cent; silicon, 0.51 per cent; manganese, 0.77 and 1.01 per cent; sulphur, 0.066 and 0.057 per cent; and phosphorus, 0.052 and 0.056 per cent.

This casting was scheduled to be poured from one converter heat and one electric furnace heat, mixed, but owing to trouble with the electric furnace we were obliged to pour it entirely of converter steel. Every precaution was taken to relieve this casting so that the shrinkage would not result in hot checks, the sand being dug out from around the heads and the cope lifted off the casting about 30 minutes after pouring. We were naturally somewhat afraid that we would have hot checks in this casting, but when the cope was lifted off and we found the casting torn in three pieces our feelings may be more easily imagined than described. Within a few days the same casting was poured successfully of electric furnace steel which analyzed as follows: Carbon, 0.30 per cent; silicon, 0.38 per cent; manganese, 0.85 per cent; sulphur, 0.021 per cent; and phosphorus, 0.019 per cent.

We afterward successfully poured these large castings and also large stern frames, sometimes with electric furnace steel alone and sometimes with electric steel and converter steel mixed. The analyses of several heats on which we successfully poured castings of this class are given below:

Kind of heat	Carbon Per cent	Silicon Per cent	Mang'se Per cent	Sulphur Per cent	Phosph'us Per cent
Electric	0.26	0.38	0.82	0.02	0.024
Electric	0.37	0.42	0.94	0.019	0.033
Converter	0.37	1.10	1.51	0.047	0.045
Electric	0.27	0.78	0.94	0.030	0.036
Converter	0.27	0.24	0.67	0.045	0.046

Examination of these analyses shows that the average sulphur in the two castings poured of electric and converter steel mixed is 0.033 per cent in one case and 0.038 per cent in another.

Naturally, in the rush of war work we were too busy to keep very complete records, but our experience convinced us that the electric steel was superior to the converter steel

from the standpoint of hot checks and we had several cases besides those given above where steels of practically identical analyses as regards sulphur ran true to form in the matter of hot checks, the converter steel giving considerably more trouble than the electric.

Experiences at Easton

Our Easton shop at the same time was running a 6-ton basic electric furnace side by side with a 2-ton converter. In their electric furnace practice they did not work for as low sulphur as we did at High Bridge, but after they had been running a couple of months they were convinced that the electric steel castings were so much more free from hot checks that there was practically no comparison between the two steels. They had an experience on a large stern frame which was practically the same as ours at High Bridge—a converter steel casting cracked so badly in the molds that it could not be used at all. The same casting poured from electric steel with a little converter steel to fill up the heads came out practically free from hot checks.

At Easton one of the regular lines of manufacture is castings for track work which are poured from a hard grade of carbon steel. These castings are of intricate design and the men in charge of that foundry have been making them regularly for 15 or 20 years. In talking with them they remarked that during the 15 years they had poured them of converter steel they had grown to regard hot checks in these castings as a matter of course, but that after a short experience with the electric furnace steel they were able to turn out these castings practically free from checks with no more care in handling, and in fact, in many cases, with less care than was used for the converter steel.

We do not wish to be understood as stating that we believe that sulphur has nothing to do with hot checks in steel castings, but we do feel that sulphur is by no means the only thing which makes converter steel liable to these defects. In fact our own individual opinion is that although sulphur is a contributing cause it does not have as great an

effect in causing hot cracks as does the method of manufacture of the steel.

Data on Electric and Converter Heats

No. of Cast	Date	Heat No.	Carbon	Silic'n	Mang.	Sulp.	Phos.	Remarks
			Analysis — Per Cent					
1	6/12	E491	0.28	0.24	0.47	0.032	0.023	
4	6/13	E497	0.34	0.51	1.40	0.014	0.040	
1	6/15	E505	0.35	0.24	1.00	0.017	0.037	
3	6/19	68578	0.30	...	0.87	0.047	0.049	2 cracked, torn
2	6/19	68579	0.29	0.47	1.11	0.046	0.050	1 cracked, torn
2	6/20	68592	0.27	0.56	0.84	0.065	0.041	1 cracked, torn
1	6/20	68593	0.30	...	1.13	0.055	0.043	1 cracked
2	6/21	68609	0.26	...	0.98	0.057	0.049	1 cracked, torn
1	6/25	68657	0.27	0.38	1.00	0.070	0.045	
2	6/26	68675	0.24	...	0.80	0.064	0.040	1 cracked, torn
3	6/26	E528	0.27	0.19	1.31	0.016	0.020	
2	6/26	68673	0.28	0.56	1.07	0.065	0.043	
1	6/27	68691	0.26	0.61	0.94	0.055	0.048	
5	6/28	E532	0.31	0.33	1.00	0.015	0.027	
1	6/28	E533	0.35	0.24	1.00	0.018	0.031	
3	6/29	E538	0.30	0.28	0.93	0.014	0.020	
	6/14	68562	0.33	0.38	0.94	0.054	0.047	2 cracked, torn
	6/14	68528	0.28	...	0.88	0.038	0.045	1 cracked, torn

Discussion—Electric Versus Converter Steel

Mr. Maher.—Do I understand that you met the physical and chemical requirements without any difficulty but you were troubled with hot checks?

Mr. Hanks.—We were able to meet conditions as to the checks.

Col. A. E. White.—I believe that the cracks are due to heat temperatures of the steel as much as to molding conditions. The inaccessibility of the converter makes it hard to determine the temperature of the steel before pouring, whereas with the electric furnace the steel can be tested by the film, rod and spoon tests.

The Effect of Sulphur on Steel Castings

By A. E. White, Ann Arbor, Mich.

It is not the object of this paper to add any new evidence to that which already has been presented. There has been no opportunity, since the writer was requested to prepare a paper on this subject, to make experiments and tests. It is the object of the paper to plead for a thorough survey of the items which affect the quality of steel castings and to judge of their acceptability on the basis of the properties they possess rather than to lay undue emphasis on one or more disputed points.

Considerable has been written concerning the effect of sulphur in steel. Numerous writers have pointed out that sulphur in percentages much above 0.04 or 0.05 gives material showing undesirable qualities. Now and then some one suggests that sulphur in percentages greater than 0.04 or 0.05, possibly as high as twice the values given, in no way affects the quality of the steel. Much that has been written is in the way of exposition and is not supported with evidence. Furthermore, a considerable amount of the evidence submitted is so beclouded by other factors that the data is valueless. Practically all of the literature discussing sulphur deals with its influence in rolled or forged steel and not in cast steel. Between cast steel on the one hand and rolled or forged steel on the other, there is, in the writer's opinion, a vast deal of difference. Therefore the observations on the influence of sulphur in rolled or forged steel, relatively speaking, may have little bearing if applied to cast

steel. This, briefly stated, is the status of the question at the present time.

Factors Affecting Quality of Castings

Broadly speaking, there are five main factors which affect the quality of steel castings. These are design of castings, composition, molding practice, steelmaking practice and annealing practice.

Included in the molding practice may be listed the kind of mold, whether of green or dry sand; method of venting; weight and location of riser; method of gating; character of cores; length of time mold is kept around metal after pouring, etc.

In the steelmaking practice may be included place of recarbonization, whether in furnace, converter or ladle; size of heat; number of castings to be poured from a given ladle; temperature of pouring, etc.

In the annealing practice may be included the evenness of furnace temperature; the temperature employed; the time consumed in bringing to heat; the time at heat; the time consumed in cooling; the type of castings placed in a given furnace, whether all light, all heavy, or mixed; the type of furnace used, whether a furnace designed for heavy castings employed on light ones or vice versa; character of flame, whether oxidizing, reducing or neutral; etc.

There are times when too little attention is given to the question of design of steel castings. Many designs are made by men who know too little about the characteristics of metal when it is changing from a liquid to a solid. Much improvement in the matter of quality of finished castings could be brought about by closer co-operation between the designer and foundryman, and it is trusted that as time goes on, this suggested closer co-operation will become more and more common.

Purchaser Depends Upon Foundryman

In general, the steelmaking and molding practice is of an acceptable character. In large measure, however, the purchaser is in the hands of the founder since it is not feasi-

ble for him to employ as expert a steelmaker or steel founder as the steel-casting operator can afford to do, and only by the employment of an abler steelmaker or founder can he expect to properly pass upon these phases of the process. Even if he can get a man of suitable experience, it is questionable if he should employ him, for by so doing, a status of divided authority in the steel castings plant would develop, and such a condition would be most unsatisfactory and in fact, quite impossible. Also, by chemical, physical and visual tests the purchaser can gather sufficient information regarding the character of the castings to decide whether or not they are acceptable, so that he is not as much at the mercy of the founder as might appear to be the case at first glance.

The writer believes much greater attention should be given to the matter of annealing in the future than has been accorded it in the past. As a rule, steel founders have not awakened to the latent possibilities of scientifically controlled annealing. Many furnaces bear indications that the only things thought of in their design are walls, a floor, a roof, and some kind of ports for the admission of heat.

There seems to be an utter disregard of such questions as fuel efficiency, through proper combustion and control of heat losses by radiation and by the stack; character of the flame, whether oxidizing, reducing or neutral; scientific temperature control, for in most furnaces there is as much as 200 degrees Fahr. difference in temperature in different portions of the same furnace; accurate temperature measurements, for such furnaces as have pyrometers usually have only one and it is neither frequently calibrated nor does it necessarily record the real conditions in the furnace because of the varying temperature distribution in the same; and care in the selection of only pieces of approximately the same cross section for each furnace per anneal, for there exists a more or less haphazard method of placing castings with different cross sections in the same furnace with the resultant of either overheating the thin ones or failing to remove the dendritic structure in the thick ones.

It was the writer's privilege in the fall of 1916 and the winter of 1916-1917 to visit nearly all of the important steel casting plants in the eastern half of the United States. It was also his privilege to have under his supervision the inspection of all of the steel casting plants producing ordnance material for the United States army from January, 1918, until he left the service in March, 1919. As a result of this experience, he has come to feel to a greater and greater extent that the acceptance of steel castings should be placed on a broad basis and that the minute scrutiny of castings for a few hundredths of a per cent of sulphur is both irrational and unwise.

To talk about the effect of an increase of 0.01 or 0.02 per cent of sulphur when by improper annealing, improper steelmaking or by improper foundry practice, properties many times worse than those produced by sulphur are acquired by the steel, is, in the writer's judgment, placing undue emphasis on the wrong factor.

Sulphur in steel may increase blow holes—it is granted that this is a disputed point—but assuming that it does, it will not do so to nearly the same extent as an improper temper to the mold; improper venting of the mold or core, especially the core; or an improper pouring temperature. It may increase shrinkage, but it will not do it nearly as much as an improper casting design, an improper pouring temperature, or too rapid a heating or cooling during the annealing. It may decrease the metal's resistance to shock but not to the degree that a poorly designed casting will, or one in which the metal has been overheated, burned or underannealed with the dendritic structure still in evidence.

It was because of the feelings expressed in the preceeding paragraph that the writer championed, while connected with the ordnance department, a more liberal specification as applied to sulphur, though accompanied at the same time with such a method of inspection at the casting plant consisting of an examination of test bars, annealing lugs, visual examination, etc., that the real quality of the castings, or as near real as could be obtained, might be ascertained.

Discussion—The Effect of Sulphur on Steel Castings

Mr. McCauley.—About six years ago when we were using coal as the fuel in our furnaces, we were getting from 0.042 to 0.07 in sulphur and were having checked castings. We went to the use of fuel oil about three years ago and frequently have had heats analyzing as low as 0.028 in phosphorus and sulphur, and we still have checks. We have been unable to prove to our own conclusion definitely that the difference in the sulphur makes any appreciable difference in the amount of checks in our castings.

The Chairman, R. A. Bull.—I hope that the converter foundrymen who, perhaps especially during the war have been laboring under greater difficulties with respect to high sulphur content are able to submit more information as to tests than open-hearth founders, so that anybody can make his own deductions. In our own case, or in the case of others making open-hearth steel, of course, it isn't an extremely difficult matter to keep our sulphur down to the limit, but I know from a somewhat limited experience in converter practice that at times the extreme shortage of suitable coke made a very difficult problem for the converter foundries.

Mr. E. F. Cone.—We all know that early in the war specifications had to be changed for steel castings to meet all the conditions and to get out the necessary product. I would like to ask Colonel White whether in his experience he has noted any practical observation as to whether the increased sulphur did any harm to castings that were in service; whether he ran across any data of that kind?

Col. A. E. White.—The very fact that the war ended as soon as it did has resulted in our being unable to obtain any real actual data with regard to the increased amount of sulphur in steel castings that went into ordnance work. So far as I have been able to get information from the records, the cast-

ings with the higher sulphur content were giving as good service as the castings which were held under 0.04 and 0.05 per cent, which was the case at the very beginning of hostilities.

Commander Rhoades.—The U. S. S. Georgia had in 1909 fourteen 6-inch gun mounts or stands that broke in service and that had to be replaced. We microscoped them and looked them over, analyzed them, tested them, and they all ran high sulphur, around 0.06 and 0.07, but we never broke any that we made with 0.04 on the same job. They were large castings, weighing about 2000 pounds. I would like to ask Mr. White if in his experience he has observed that it is more difficult or less difficult to break up the dendritic structure and the bands and the ferrite in steel with a large amount of inclusions than one that has very little. In other words, we get a distribution of carbon in treatment. We can disseminate that carbon through the ferrite and get a uniform, nonbanded, nonferritic steel with low sulphur, easier than we can get it where we have large particles in the inclusions. We took a forging from a 5-inch gun at Bethlehem in 1914 in which the bands were the most remarkable I have ever seen. The streaks were uniformly white ferrite areas full of manganese sulphite inclusions in the center, and they couldn't treat that out. We knew it was sulphur from the color and sulphur prints, and from a piece a foot square we pulled 15 bars, none of which showed over 3 per cent elongation, although when we got off the streak we got up to 20 per cent elongation.

Col. White.—I trust none of you will misunderstand me with regard to the sulphur content. I have tried to make myself perfectly clear to the extent of stating that provided we had high grade castings and the castings were uniform with regard to the molding practice, annealing practice and design, that a low sulphur casting would then be preferable to a higher sulphur casting. The point that I tried to make, however, was that in my judgment the variations in designing and in molding practice and in annealing practice offset the variations that might be due to one or two hundredths of a per cent of sulphur. These streaks that we see in steel castings are termed, I presume, ghost lines, and I

presume it is generally conceded that the ghost lines are due to the presence of phosphorus and that the phosphorus present in the steel in the manner in which it is, prevents the ferrite on annealing from distributing itself evenly throughout the casting, and that once we get that condition it is very difficult indeed to eliminate it. In fact, I don't know as any successful treatment has ever been devised where it can be eliminated. The only method whereby I know we can eliminate it is to quench the casting, but then if we draw it back the ghost lines return again. I don't know as it is usually felt that the ghost lines and streaks are due to sulphur. It is due to the phosphorus content, and, of course, we are not at this present time particularly concerned with the phosphorus content, although I realize that the two to a certain extent go hand in hand. The fact that there were streaks of manganese sulphite present in the ghost lines means, of course, that the metal was dirty, but at the same time I am not altogether convinced that the reason why those castings failed was due to high sulphur. The very fact that the castings had these ghost lines might indicate that this condition was very materially weakened through the influence of the phosphorus, and that failure possibly might be laid to phosphorus as much as to sulphur.

MR. LOCKE.—In connection with the matter of the effect of sulphur on castings from the producing standpoint, I collected data on some 1600 consecutive heats, involving about 35,000 tons of basic open hearth, in order to see if there was any appreciable effect of sulphur on the cracks. Our sulphur runs entirely between 0.020 and 0.030, and I found that the castings that cracked at 0.030 were about three times as many as the castings that cracked at 0.020, and the curve is very close to a straight line. I took a large number of heats in order to avoid any local conditions, such as molding or temperatures of the heat, and felt by doing so that I eliminated those things. Now, when it comes to phosphorus I found that the curve was practically horizontal. In other words, I could not see that there was any effect at all which probably could be expected, so that as a result I feel that apart from

the service of the castings after they are completed, the sulphur is very injurious from the producing standpoint.

Mr. C. S. Koch.—Regarding the matter of hot cracks, I believe that some foundrymen have more trouble the higher the sulphur, but this is a matter for each individual foundryman to determine for himself.

I think Professor White has been rather modest, in omitting from his paper much that he learned from the ordnance department. One point which he could have emphasized was that very frequently a list of 30 or 40 heats, which had been rejected by the inspection division of the ordnance department, by reason of their failure on physical tests, was referred to Washington for final decision. In the course of time, many such lists were compared with other similar lists from other foundries, and in the comparison of these, I do not believe it was very often found that high sulphur was the cause for their failure on the physical tests. In other words, there were many times when the sulphur and phosphorus were extremely low, and having failed in the physical tests as often as those which were high in sulphur and phosphorus. After a considerable number of these batches of rejected heats had been handled and compared, it was interesting to see that almost invariably the foundry was given the opportunity of reannealing, and in almost all cases the second lot of tests from the same heats would be returned as having satisfactorily passed the physical tests.

In fact, it is my opinion that if all of the cases of rejected heats were compiled, as well as all the data concerning reannealing, etc., it would have been almost invariably found that the cause of rejection, or failure to pass physical tests, was due to poor heat treatment.

Briefly, our whole trouble last year in the ordnance department was not analysis, not how the steel was made, or in what kind of a furnace, but was absolutely and almost entirely a matter of poor annealing equipment and poor annealing knowledge.

The Acid Electric Furnace Process

By L. B. Lindemuth, New York

In considering the electric furnace as a steelmaking instrument, whether acid or basic, we must always bear in mind that it offers the one method of manufacture by which we can obtain commercially either oxidizing or reducing conditions, and are therefore able to produce high quality steels at prices which are not prohibitive.

It will be necessary in this paper to assume that everyone is familiar with the metallurgy of the basic process, and it will, therefore, be mentioned only to point out differences or similarities between it and the acid process.

The electric furnace lined with sand, with the steel covered with silicious slag, varies from the basic-lined furnace with a basic slag, in that all of the constituents of the steel, except silicon, being in themselves basic, hold a different relation to the slag and lining, which are acid, than they do in a furnace where the bases are always in a very material majority. This difference in relationship affects not only the constituents of the steel but also influences the effect of the reducing conditions which make the electric furnace a superior steelmaking container.

How Phosphorus is Removed

In the basic furnace, phosphorus is removed from the steel by producing an oxidized condition. Slag containing the phosphorus is then scraped out of the furnace and a second slag of a definite composition is made up and introduced in any desired volume. In the acid process, however, the removal of phosphorus which is itself an acid, is not possible in the presence of an excess of silica, which is the stronger acid.

It is, therefore, unnecessary in the acid process to remove the slag provided it is possible to produce the necessary reduc-

ing conditions with the slag resulting from the melting-down operation. The acid process is, therefore, a one-slag process, but it is necessary to purchase scrap with the phosphorus and sulphur content below the maximum allowed in the finished steel, and in most cases the economy effected by a one-slag operation, compared with the basic process, would be offset by the premium paid for low-phosphorus scrap. To produce steel of a uniformly high quality by the electric process we have only to consider the production of a uniformly deoxidized silicious slag.

Unlike the basic process from which we can produce slag of a definite composition and a definite volume, the acid slag varies considerably, both in analysis and quantity. The controlling feature in the operation of the acid process seems to be the quantity of iron-oxide present at the time the heat is melted, irrespective of whether this oxide is introduced with the steel scrap as rust, or whether it results from oxidation due to air leaks in the furnace, or from the addition of iron ore. The slag volume in the acid process is controlled directly by the action of this iron oxide and silica.

Unfortunately, scrap in any scrap yard is variable with regard to rust. A small coating of rust on light scrap such as turnings, which is, in certain proportions, a desirable scrap for an electric furnace, represents a much greater percentage of the scrap than the same coating of rust on heavier scrap.

Oxidation Due to Leaks

The amount of oxidation due to furnace leaks is a variable with every heat, so that oxidation from this source is not necessarily at all consistent. Scrap charged in the evening and allowed to stand in the furnace until morning, or charged Saturday night and allowed to stand until Sunday or Monday will become oxidized, the amount of oxidation depending upon the weight of the individual pieces of scrap and the care which was used in sealing the furnace after it was charged. It, therefore, follows that the amount of iron oxide in a furnace during melting is a variable which it is impossible to estimate. With the iron oxide varying between

heats, the slag volume will be similarly affected and there is no means of determining, before the heat is tapped, what percentage of slag volume there is.

The reducing conditions necessary for the production of the highest grade steel and for making heats within the specifications desired require a slag with a definite composition. To secure the proper slag without delaying operations, its composition must be judged solely by its appearance, and the fact that this slag is not obtained through reducing conditions alone makes the acid electric process one which requires more skill and judgment on the part of the furnace man than the basic process.

The acid slag after melting and before any additions are made is principally a complex silicate of iron and manganese, containing usually about 50 to 60 per cent silica, the remainder being principally oxides of iron and manganese. Practically all the manganese of the charge with the exception of about 10 per cent passes into the slag as oxide. The percentage in the slag, of course, will depend upon the slag volume.

The oxidation of the bath, and of the subsequent additions of manganese, appears to be controlled by the percentage of FeO in the slag. Whether the excess FeO is combined in some form of silicate, or whether there is free iron oxide I do not know, but whatever form the iron oxide is in, it acts as an oxidizing agent on carbon, silicon and manganese.

Further, this iron oxide cannot be appreciably or satisfactorily reduced from the slag by adding coal or coke dust as in the basic process for two reasons. First, a silicate in which the acid constituent is in excess is more difficult to dissociate than a silicate in which the bases are in excess, as in the basic process, and further the iron is more stable in a silicate in which the iron base is the predominating base, as in the acid process. In the basic process, with CaO and MgO the controlling bases in a basic silicate, iron oxide, whether free or combined with the other bases as a complex silicate, is easily reduced by coal or coke.

The second reason why it is impractical, and perhaps impossible to reduce FeO from the acid slag by coal or coke is that at the high temperatures in the vicinity of the arcs, SiO_2 is reduced by carbon. This phenomenon is familiar in the bessemer process, where, when a certain high temperature has been reached, silicon in the bath increases during the blow.

In the acid process, therefore, if the slag is subjected to reducing conditions before it is of the proper composition, silicon will be reduced and the bath will contain a percentage of silicon varying with the intensity of these conditions and their duration.

As the iron oxide is reduced with difficulty, it must therefore be replaced by a stronger base. This is partially accomplished by the addition of lime. Manganese ore, if free from iron, should also be used for the same purpose. It is by replacing iron in the slag with calcium and manganese that it is possible to produce the necessary reducing conditions and secure uniform retention in the bath of subsequent manganese and silicon additions. Fortunately a slag with the proper percentage of lime and manganese can be determined by its appearance.

Similar to an Open-Hearth Slag

An oxidizing acid slag such as obtained after melting down is black and opaque or slightly glassy similar in all respects to a common acid open-hearth slag which it really is, chemically and physically. As soon as a heat is melted and the carbon is observed to be sufficiently low, lime should be added immediately up to 20 or 30 per cent of the slag volume, also it is preferable to add manganese ore sufficient to give 10 to 15 per cent MnO in the slag. When the slag contains sufficient lime for practical purposes it will no longer be black but will turn to a green or robin's egg blue and when cooled in the air, the surface will turn black or brown depending upon the proportions of iron and manganese oxide, black if it contains too much iron oxide, and brown if the iron oxide is sufficiently removed. Coke dust or coal should be used dur-

ing the interval of adding lime and manganese ore, and until the heat is tapped to prevent any further oxidation of iron. If all the constituents of the slag are actually combined with nothing in suspension, and the furnace is free from air leaks and working under a normal reducing atmosphere, a translucent, almost transparent, glassy slag of yellowish green or greenish blue is obtained. With this transparent slag and the greenish blue slag coated with a chocolate brown, reducing conditions are the best that can be obtained by the acid process. Subsequent additions of manganese and silicon will result in uniform losses and therefore give uniform results in the finished steel with respect to these elements.

A typical analysis of a proper finishing slag is as follows: SiO_2, 58.70 per cent; CaO, 21.25 per cent; MnO, 12.01 per cent; FeO, 3.10 per cent; MgO, 1.15 per cent; Al_2O_3, 3.35 per cent; P, 0.003 per cent; and S, 0.005 per cent.

If the slag during these operations shows a tendency to be porous or spongy it is still in an oxidizing condition. A proper acid slag should be free from sponginess or indications of gas pockets.

Three Alternatives

Three alternatives to the ordinary scrap melting, one-slag, process can be used to overcome the variables introduced by rust or other oxidation, namely:

1.—Duplexing from a converter, or open-hearth furnace.
2.—Slagging-off immediately after the charge is wetted.
3.—Tumbling the scrap before charging to remove rust.

The first of these is possible only in few plants. The second, to my mind represents the only satisfactory method of operating the acid process under the conditions found in the majority of electric-furnace plants. The third is expensive, impractical, and does not prevent the variations due to oxidation in melting, but would produce more uniform results than the melting of scrap with variable degrees of rust.

It is important that the carbon content of the bath be as low as, or lower than that desired for tapping, before an effort is made to reduce the iron oxide percentage of the slag.

Iron ore added after the lime and manganese addition, delays the operations and produces a slag which is thin and scorifying.

The yield of steel from charge to ladle is higher in the one-slag acid process, than in the two-slag basic process on account of the losses in the latter due to "slagging off." However, if the acid process were carried out with two slags the losses would be about equal.

Open Questions

Statements that the acid process produces steel with fewer slag inclusions, and of greater fluidity for castings, than the basic, are open questions. My observations of inclusions have led me firmly to believe that foreign inclusions are of far more frequent occurrence than any possible inclusions resulting from reactions within the steel made by any modern process. If inclusions are found where large masses of steel are not involved, such elements as ladle linings, nozzles, washes, pouring, and molding should be thoroughly investigated before any connection can be laid upon whether a process is acid or basic. From the point of view of inclusions resulting from a process, the basic electric process gives conditions more favorable for their minimum than the acid process.

The fluidity of acid electric steel might be greater on account of the almost invariably higher phosphorus. Unfortunately this feature of the acid process has never been determined. A simple set of experiments carefully carried out could determine this, and it is to be hoped that in the near future this question which is of importance particularly to foundries casting small and intricate shapes, will be answered by actual figures.

No difference has been found in the physical properties of well made acid electric-steel castings or forgings compared to basic electric-steel, and for the purpose of castings, therefore, we may consider the product the same in this respect.

Briefly, we must consider the acid electric-steel process as a slag-making process. Oxidizing conditions caused by rust and by furnace operations influence the quantity of slag, and this quantity is always a variable. Iron oxide in the slag

must be replaced by a stronger base to remove it, and reducing conditions maintained to prevent its further formation. Scrap must be purchased and selected with care in order that phosphorus and sulphur will be within specified limits in the finished product. This is accomplished only at an advance in price. Good judgment and skill on the part of the melter, as well as an ability for quick observation, will determine the results which will be obtained by this process. Until the advantages of more fluidity and greater freedom from inclusions attributed to acid steel can be substantiated by facts I would say that the basic electric-furnace is the superior steelmaking instrument of the electric processes.

Discussion—The Acid Electric Furnace Process

MR. LEWIS B. LINDEMUTH.—In discussing slags with a certain degree of basicity or acidity the analysis of the slag one unit of FeO combines with one unit of SiO_2, the percentage which represents the percentages of elements or compound by weights does not represent the true condition of the slag as to whether it is basic or acid. For example, if we assume that of FeO would be 54.5 per cent.

If we then assume that one unit of CaO combined with one unit of SiO_2 the degree of basicity would be the same but the percentage of CaO would be 48.2 per cent. For this reason it follows that one unit of CaO will replace 1.28 units of FeO. One unit of MgO will replace 1.9 units of FeO. MnO is so close to FeO that they can be considered equal.

In figuring on a slag then, it is necessary to correct the figures given in analyses to conform with the replacing value of the different compounds. This can be readily illustrated by

two acid electric furnace slags of apparently an entirely different nature from analysis. They are as follows:

	Slag No. 1 Per Cent	Slag No. 2 Per Cent
SiO_2	53.46	56.60
CaO	7.60	20.00
MnO	20.22	9.08
FeO	11.38	4.44
MgO	4.86	4.80

Slag No. 1 figuring the bases in terms of FeO equivalent represents 49.07 per cent, while slag No. 2 on the same basis represents 49.09 per cent FeO equivalent.

All slags in the electric furnace will tend to adjust themselves to a certain degree of basicity regardless of whether the bases are iron oxide, lime, magnesium oxide or manganese oxide, and this degree of basicity will be, in terms of iron oxide equivalent, between 44 and 50 per cent.

If, in melting down, a slag is high in iron oxide, as it almost invariably is, it would tend to pick up from the bottom of the furnace enough silica to bring its basicity within the percentages that I have mentioned. If on the other hand, there are not sufficient basic oxides and the slag is high in silica the slag will be thick and viscous and will tend to relieve itself of silica by having silica reduced and silicon passed into the metal. As an example of slag high in bases in which it tended to automatically stabilize itself, the following analysis represents such a heat:

	Slag No. 1 Per Cent	Slag No. 2 Per Cent
SiO_2	39.12	55.10
CaO	6.55	5.27
MnO	25.35	23.63
FeO	23.77	11.30
MgO	.22	.23

The iron oxide equivalent of bases in slag No. 1 is 57.77 and in slag No. 2, 41.98 per cent.

On the other hand, seven slag and metal tests taken throughout a heat in which the iron oxide equivalent of the bases vary between 36 and 38 per cent, the residual silicon in the steel increased from 0.11 to 0.32 per cent without additions of silicon.

I have stated in my paper that iron oxide cannot be appreciably or satisfactorily reduced from an acid slag and that it must

be replaced by a stronger base. To demonstrate this I will give you as an example some tests taken throughout a heat after the slag was in workable shape and apparently had reached its equilibrium. The example is typical. These results show how FeO in the slag was reduced from 10.67 to 4.60 per cent, but which was not accomplished without increasing basicity.

	No. 1 Per Cent	No. 2 Per Cent	No. 3 Per Cent	No. 4 Per Cent
SiO_2	60.30	58.44	56.60	57.50
CaO	15.00	18.10	20.00	18.95
MnO	4.58	6.20	9.08	11.60
FeO	10.67	9.30	5.77	4.60
MgO	5.84	4.53	4.80	3.80

The iron oxide equivalent of bases in these slags are 44.96, 46.48, 47.28, and 47.28 per cent respectively. In studying acid slags in which the bases are corrected to the equivalent of iron oxide it is noticed that after a slag has reached its equilibrium, additions of lime, manganese, ore, etc., will upset its equilibrium only for a very short time and that throughout the heat after the iron oxide equivalent has been established it will remain practically the same.

One common trouble in the acid furnace which upsets the equilibrium of the slag is the sand from which the furnace bottom is made. The most general trouble appears to be that of having a sand which is too refractory. Such a sand will not sinter into the bottom and when the charge is melted will float to the top and give an excess of SiO_2. A good furnace botton sand should contain between 96 and 97 per cent SiO_2. If the sand runs higher than this in SiO_2 it should be mixed with some lower grade sand so that the mixture will contain between 96 and 97 per cent.

It would seem that the glassy, transparent slag is the most desirable for in nearly all cases it shows the lowest percentage of FeO. The blue and green slag with the chocolate coating will produce satisfactory results and are the easiest to obtain. No heat should be tapped, however, as long as the slag shows a black coating. The reason why some of these slags are green or blue or gray, I do not know, but it is probably from some combination of iron, manganese and lime, or possibly alumina in their various forms depending upon the degree of oxidation.

Comparison of Existing Methods of Measuring the Temperature of Molten Steel

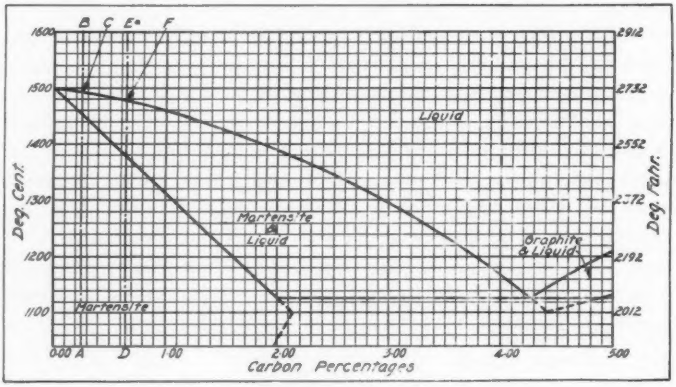
By F. W. Brooke, Philadelphia

A large number of trials and experiments have been carried out by steelmakers along with the very commendable support of the makers of pyrometers to try and put the measurement of molten steel upon a scientific and fairly reliable basis. Most of the practical investigators have known all along that the measurement of actual temperatures to any degree of accuracy is at present too much to aim for, and have contented themselves with the effort of finding some indication such as a reading on an instrument which tells them when the steel is at the best temperature to produce either a certain type of casting or a first-class ingot with the particular composition of steel they are handling, and that each time this reading is obtained the steel is at its best pouring temperature. In other words comparative tests have been their chief aim.

Use of Pyrometers

Of the scientific instrument methods, we may consider thermo-couples, radiation pyrometers and optical pyrometers. The thermo-couple for temperatures of heat-treatment has proved valuable. In the measurement of molten steel, however, only the rare metal couples can be considered, and even these do not withstand the very severe conditions of a bath of molten steel. Protective tubes, such as quartz tubes, have been tried, but have certain disadvantages. The mechanical strength of a long tube at the high temperature is inadequate; the chemical reaction of the slag in the case of basic operation is undesirable; and the varying thickness of the coating of slag to the tube as it is pushed through the slag causes a varying lag of temperature from the steel to the couple.

The radiation pyrometers, of which the Thwing or the Foster type of fixed focus pyrometer appear to be most satisfactory, require no focusing and the method of handling them is simple. Both of these instruments also have an attachment for taking care of the change in black body conditions from true black body conditions when steel is poured from a furnace or from a ladle. The accuracies of these attachments are not so important, as they are the same for each heat as long as the steel is in a completely molten state. The first obvious objection is that owing to the slag covering in the furnace, and the difficulty and objection of maintaining an



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uncovered patch, the temperature cannot be read until the steel is being poured into the ladle. While this only allows for correction of temperature in one direction, it still has several valuable advantages. If the temperature of the steel is too low, preference can be given to the heavy castings of large section and the pouring operation carried out as rapidly as possible. If the temperature is on the high side, the steel can be left in the ladle or preference given to all the small castings requiring a relatively higher temperature, but perhaps the greatest value is a check and guidance for the melter and the foundry superintendent on the now existing more or less crude practical

methods to be explained later. In the open-hearth furnace, when consecutive heats are being run to the same analysis and same conditions, a certain difference of temperature between the steel and the slag may be assumed, but this is not very reliable.

The principal objection, however, in the use of radiation pyrometers is the difficulty of always being able to focus through a clear atmosphere and onto a clean stream of steel. In actual practice, it is found that smoky atmospheres and incandescent gases are constantly interfering, while in many furnaces the slag comes out of the teeming spout along with the steel and it is very difficult to know which of the readings recorded represent true conditions, or the same conditions as on the previous heat. There is also a tendency on the part of the observer to record the highest reading on the instrument and interference of a small amount of incandescent gas can escape notice. The following readings are typical of many tests made of a stream of steel leaving the nozzle of a ladle when pouring castings of easy section of about 30 to 100 pounds in weight and 0.25 to 0.35 per cent carbon, by the same instrument and the same observer, the resulting castings being of first class quality.

	Heat No. 7			Heat No. 23	
Mold	Degrees Cent.	Degrees Fahr.	Mold	Degrees Cent.	Degrees Fahr.
1	1510	2750	1	1530	2790
2	1560	2840	2	1540	2800
3	1515	2760	3	1210	2210
4	1740	3170	4	1560	2840
5	1530	2790	5	1490	2710
6	1580	2870			

It is obvious that the readings on the fourth mold of heat No. 7 and the third of heat No. 23 were decidedly off, although every care was taken on both these heats to get uniform conditions and the error is undoubtedly due to incandescent gases and smoky atmosphere. Results both better and worse were obtained, and these are given as typical when every care was taken.

Practically the same limitations are noticed with optical pyrometers as with the fixed focus radiation type, the added disadvantage being that with every type of optical instrument there is more of the personal element brought in by the matching of intensities or the matching of colors. On the other hand, they are not so liable to damage by the too close proximity to the molten metal, as an observer has less fear of sticking a long tube up to the stream than of bringing his face too near.

Of the practical methods known, the film, rod and pouring tests are in constant use at various electric furnace plants, and they are all depending upon uniform conditions existing when each test is made. The use of the film test originated from the crucible steel practice, it being the best practice in making tool steels to first close all the melting shop doors; then to pull the pots after the required stewing and remove the lid and slag; make any additions and then carefully watch the bright surface of the steel for the first sign of an oxide film forming, this being the sign to commence pouring operations. In the absence of drafts, this served as a fairly reliable temperature indicator, as the crucibles and the mass of steel were usually the same, while the varying composition of the steel could be allowed for by pouring as soon as the first speck appeared, or so many seconds later. In electric furnace practice, this consists of using a steel spoon of uniform capacity, dried out thoroughly over the bath, and giving this a total covering of slag in the furnace. A sample of steel should then be taken, which fairly represents the whole bath, remembering that when a door has been left open for some time the steel near the door has become chilled, and with steel made in an electric furnace where all the heat is applied at the top only, the temperature of the steel directly under the slag is higher than the temperature of the steel near the bottom. Where this is the case, the bath must be thoroughly rabbled before any sample is withdrawn, and even then the sample should be taken at a place equidistant between the electrodes and half way down the bath, so as to arrive at an average temperature. The measurement of the tempera-

ture is then indicated by the length of time it takes for an oxide film to completely cover the sample after the sample is taken from the bath. This method is also influenced by the composition and physical condition of the bath, as for molten steels of the same temperature this time varies, principally with the carbon contents, the silicon contents, other alloy contents and the state of deoxidization. Therefore, final comparisons must only be made between steels of approximately the same composition and when the furnace is ready to pour. Care must be taken to keep the sample away from drafts and to have about the same amount of steel in the spoon each time. To show the range of this test it has been noted that first class high-speed steel ingots of a composition approximating carbon, 0.65; tungsten, 17.5; chromium, 3.75, and vanadium, 1 per cent, were produced when the film (with a later characteristic wrinkling of the surface) was formed directly the sample spoon came through the door, while good castings of about 0.25 carbon and weighing from 30 to 200 pounds were produced when the film took 60 seconds to form after passing the furnace door.

Factors Affecting Use of Rod Test

The rod test has been used for many years as a rough indication of the temperature of many molten metals. The first publication noted by the author of this test being made a standard practice under uniform conditions was from a large Italian steel works. This test requires the use of rods of steel of both uniform diameter and fairly uniform composition, and consist of plunging the rod into the bath of steel and gently moving it through the bath for a uniform length of time. If the steel is cold there is a deposit of the bath on the rod, if the steel is hot the bath melts away or bites into some of the rod, with all intermediate conditions indicating varying temperatures. The skin of the bar, it will be noted, has an effect on this test; a newly rolled bar with a bright scaly surface tends to show a colder bath than is actually the case. The bar before being plunged into the bath should be of uniform temperature and in some steel works this is taken

care of by bending about 12 inches or more of the end of the bar at right angles; holding the bar with the bend in a horizontal plane over the bath until it shows the first sign of sagging and then turning the end of the bar into the bath. This test again depends on the physical condition and the composition of the bath. This test is also very useful for testing the difference in temperature between the top of the bath and the bottom of the bath and is one of the best indications of the value in electric furnaces of the bottom heating type. Several tests were carried out on a furnace of the Greaves-Etchells type and not a single test showed any indication of marked difference in temperature between the top and the bottom of the bath and in every case it was shown that in a furnace of this type there is no need for any mechanical stirring of the bath. Considering the crudeness of this test and the fact that the rod had to be passed through a slag, the uniform effect of the bath on the bars were quite remarkable, both for baths that were relatively cold and hot.

Temperature is Indicated by Fluidity of Metal

The pouring test consists of using a spherical spoon of above 5 inches diameter and carefully slagging up this spoon over the bath. Dip the spoon quickly into the metal so as to get a sample of the steel from about the center of the bath. Withdraw the sample and carefully pour out the steel over the lip of the spoon at a slow even rate. The temperature of the steel is noted by its fluidity, and by the amount of steel skull that is left on the spoon. This test is the one most commonly used in steel foundries. It is simple and the very nature of the test gives confidence to the man who is responsible for pouring the heat. If he sees every drop of the steel pouring nicely over the lip he feels that in pouring from the ladle itself the castings of small section will fill up and there will be no skulls left in the ladle. This test is subject to the spoon being properly slagged up, the rate of pouring the sample, and absence of drafts.

For all these practical methods too much emphasis cannot be placed upon the fact that they are all comparative

tests only, and that they depend entirely upon uniform conditions, and attention to details. In all cases at least two of these methods should be employed. They do not of course indicate to the melter the temperature of the steel in degrees, Cent. or Fahr., but they do give him a very good indication of the degrees of temperature that the steel is either above or below the temperatures which will give him the best results for the composition of the steel he is handling, for the weight and for the type of casting he is making. In making steel castings it is important that the foundry foreman or superintendent be present when the final temperature tests are being made. He is in a much better position to know how hot the steel must be to suit the castings on the floor. To tell the melter that the castings are averaging 30 pounds and then to leave the decision regarding the temperature up to him, is not sufficient.

The question most frequently asked while trying out the above tests was: "How accurately can you measure the temperature of the steel and what temperature should the steel be when it leaves the furnace to give the best results?" The first part of the questions refers to the use of the pyrometers. On steel works where the best conditions for the pyrometer can be obtained, there is still the limitations of the pyrometers themselves. As already explained, only the optical and the radiation type offer a good field for these high temperatures and conditions, and there is little doubt that an error of plus and minus 50 degrees Fahr. in the instrument itself is all that we can ever expect. To an investigator first starting in with a new instrument he has just bought, this may not sound very encouraging as he naturally feels that if the steel proves to be 50 to 100 degrees Fahr. less than what he is aiming for he will spoil some of his castings. The other limitations of focusing and atmosphere have already been described and values given.

Determining Best Temperatures

Probably the best reply to the second part of the question is that the temperature in question is that at which the

particular steel begins to solidify, plus the loss of temperature from when the reading is taken to when the steel gets to the farthest end of the thinnest section in the casting. A further query to this second part of the question invariably was: "But how are we to know what these two values are?" The first value depends on the composition of the steel, the carbon contents being the principal factor. This can be obtained by reference to a standard carbon-iron curve, such as shown in the accompanying illustration. For a steel containing 0.25 per cent carbon, trace the line *A B* till it intersects at *C* giving a value on this curve of 1492 degrees Cent. (2720 degrees Fahr.); for a steel containing 0.65 per cent carbon, trace the line *DE* till it intersects at *F*, giving a value 1476 degrees Cent. (2690 degrees Fahr.), and so on. For other elements in the steel commonly used in castings the variation is not of importance and does not compare with the many other sources of error that crop up in reading the temperatures of molten steel in a foundry. The second value depends upon such variables as the heat of the ladle, the thickness of ladle lining, time of reading to pouring, whether molds are of dry or green sand, and thickness and lengths of the thinnest sections. All of these factors depend very much upon local conditions, and it is regarding this problem that constant consultation between the man responsible for the steel in furnace and the man responsible for making up the molds is so valuable. Final results are only obtained by the constant comparison of the quality of the final castings with the results obtained by their methods of reading the temperatures of the steel.

Discussion—Temperature Control

Mr. C. H. Booth.—I simply want to comment on what Mr. Brooke calls the skin test. We find that for small castings of thin section, timing the forming of the skin on a small ladlefull is the most accurate method of getting the proper temperatures. In the timing accurately of metal of the same analysis, steel will pretty nearly produce practically the same result in casting if the mold is correctly made.

Mr. White.—I would like to pay a tribute to the film tests, having poured more than 5000 tons of steel of the same analysis, that is, carbon between 0.30 and 0.35. I believe carbon is a governing factor to a great extent. We have not had more than three cold heats nor have we had more than eight cracked ingots.

Mr. L. B. Lindemuth—The greatest trouble in electric steel practice is making the steel too hot. Most of the tests that are commonly used in open-hearth steelworks indicate whether the steel is hot enough but do not indicate whether it is too hot. In my opinion a very satisfactory test is that where the estimate is made according to the surface tension. The hotter the steel, the greater will be the surface tension. You can tell the temperature by the way the steel rises at the edge of the spoon. You also can tell whether it is too hot. Its greatest value is that it will not let you pour the steel too hot.

Mr. F. W. Brooke.—The molders do not like the film test quite so much, especially if they are on a production basis, because it shows up the condition of the steel far better than the pouring test. If there is the slightest sign of wildness in the steel, that is, if the steel hasn't been dead killed, then it will show up in this film test.

The temperature of the steel is affected to a certain amount by the analysis of the steel. A low carbon has a higher melting point than a high carbon, although those differences are not so marked. The best way to get at it is to refer to the iron-carbon curve, which quickly will reveal the difference.

Mr. Joseph A. Steinmetz.—Do atmospheric conditions have any effect on the film test?

Mr. Brooke.—Yes. In taking a film test it is absolutely important that there are no drafts in the shop. If there is a good wind blowing through the shop it is going to spoil the film test each time.

Mr. S. H. Ourbacher.—Which test do you think is best under varying carbon conditions? Do you think the pouring test would work better—say if the carbon varied quite a bit?

Mr. Brooke.—In the first place, I really think that two tests should always be taken. Where there is any doubt never depend on one test only. My experience in going around steel mills is that the rod test is not being used enough. The large steelworks in Italy brought this rod test to a very fine degree. They decide on certain types of steel and use certain types of rods. For instance, on high carbon tool steels, they use a rod of ⅜-inch diameter and a certain composition. The time element also comes into that. The melter can leave the rod in the bath just the exact number of seconds and note the effect of it.

Mr. Brooke.—Can anyone explain the kick test?

Mr. Thomas.—The test I have been accustomed to is to move a rod back and forth through the metal until the kick is felt. It is then drawn out and the melter determines by the shape of the point or the cut whether or not the steel is ready to pour. The best way to describe what we considered a good temperature was to cut it off—just as if we were cutting a potato with a paring knife.

The Chairman, R. A. Bull.—How does the kick feel?

Mr. Thomas.—It feels like a bass biting on the line.

Mr. Lindemuth.—The kick is only a vibration, not a sudden jar, and occurs all the time the rod is in the steel. I think it represents the cutting action on the rod. When a heat is stirred with a rod, the rod comes out with what is called a rat tail. You feel very little kick when you are stirring, but if when you bring it out it looks as though somebody had bitten pieces out of it, you will get the kick. It is the centrated cutting on the rod, I think, that produces the kick or vibration.

The Chairman.—The sudden shortening of the rod and the consequent effect on the balance of it may have a great deal to do with that. Is there a vibration?

Mr. Lindemuth.—O, yes. The temperature test is partly the feeling of this vibration.

Mr. Brooke.—Is it necessary to get this kick or is it really just a variation of the rod test?

Mr. Lindemuth.—If there is any difference in the temperature of the steel and the rod after the rod gets up in temperature there will not be any kick. When the rod is brought out—and it probably is only hot—there are big gouges chewed out of the steel, showing that the rod never attained the temperature of the bath.

Report of Committee on Steel Foundry Standards

Oil Meter

The foundryman who has crude-oil-burning appliances in his foundry has occasion to know the actual oil consumed by any one or all of the many types of burners on the market. Realizing the impracticability of installing standard meters for each burner, and also that their record is of value for an average metering over a long period, your committee beg to present a design of a portable, automatically controlled oil meter. This meter may be made in any desired size and may be attached to any individual oil burner and should furnish a very accurate record of the quantity of oil consumed.

The device consists essentially of two vertical cylinders, capped and connected each with the other, both top and bottom, as indicated in the accompanying illustration. The pipe diameter may be of any dimension desired. If a pipe of a diameter much larger than 8 inches is used, a larger factor of error is introduced; and if a pipe of smaller diameter is used, the size of the meter becomes unpractical.

The operation of the meter consists essentially of filling one of the cylinders with oil through the 4-way valve to a level as indicated and at which the float will have actuated the switch and through the solenoid shut off the oil supply. It is then necessary to measure in inches the height of the oil column as indicated on the gage glass and to compute the volume of oil represented in the pipe of chosen diameter. The cock in the top connection is now open and compressed air is permitted to enter the system. The pressure as indicated on the gage will be approximately the oil pump pressure. The air connection is now closed and the meter is ready for operation. The oil in the cylinder, on its source of supply being

shut off, discharges into the burner. Simultaneous with this discharge, oil enters the cylinder which previously contained compressed air, thereby forcing the air through the top connec-

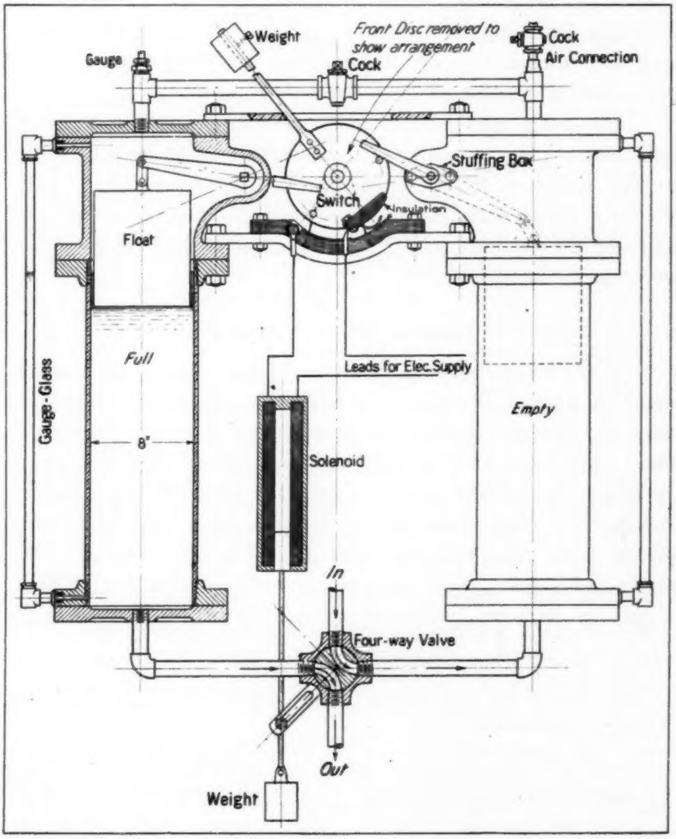

DIAGRAM OF OIL METER

tion into the emptying cylinder, the oil rising therein until the float actuates the switch shutting off the oil supply, throwing through the solenoid the 4-way valve thereby permitting oil to

flow from this cylinder to the burner and allowing oil to enter the other cylinder. It will be seen that with each throw of the 4-way valve a definite quantity of oil enters the meter. By attaching a recording counter to the valve handle to record the reversals, knowing the quantity of oil admitted per reversal and the number thereof, the quantity of oil consumed for a given period may be easily computed.

The meter may be simplified by eliminating the electrical control. In this case a pipe cap or flange is used on top in lieu of the indicated casting. The operation is the same except that the 4-way valve is manually operated and oil is allowed to enter the cylinder to a marked prescribed level as indicated on each of the gage glasses.

Linseed Oil Standards

At the present time there are many core oils on the market, many of which make claim for properties equal and comparable with the accepted basis, standard boiled linseed oil. Oftentimes, too, linseed oil is adulterated with foots and other oils. In order that all foundrymen may have available the standard specifications for boiled linseed oil and other oils, your committee have compiled this data from various sources. The method of making the various tests—both chemical and physical—may be made in accordance with an oil chemist's hand book.

Properties and Tests

Raw linseed oil from North American seed shall conform to the following requirements:

	Maximum	Minimum
Specific Gravity at $\frac{15^\circ.5}{15^\circ.5}$ C.	0.936	0.932
or		
Specific Gravity at $\frac{25^\circ}{25^\circ}$ C.	0.931	0.927
Acid Number	6.00	....
Saponification Number	195	189
Unsaponifiable matter, per cent	1.50	....
Refractive Index at 25°C	1.4805	1.4790
Iodine Number (Hanus)	....	180

Properties and Tests

Boiled linseed oil from North American seed shall conform to the following requirements:

	Maximum	Minimum
Specific Gravity at $\frac{15°.5}{15°.5}$ C.	0.945	0.937
Acid Number	8	....
Saponification Number	195	189
Unsaponifiable Matter, per cent	1.5	....
Refractive Index at 25°C.	1.484	1.479
Iodine Number (Hanus)	....	178
Ash, per cent	0.7	0.2
Manganese, per cent	....	0.03
Calcium, per cent	0.3	....
Lead, per cent	....	0.1

Properties and Tests
(China Wood Oil)

Raw tung oil shall conform to the following requirements:

	Maximum	Minimum
Specific Gravity at $\frac{15°.5}{15°.5}$ C.	0.943	0.939
Acid Number	6	....
Saponification Number	195	190
Unsaponifiable Matter, per cent	0.75	....
Refractive Index at 25°C.	1.520	1.515
Iodine Number (Hubl, 18 hours)	....	165
Heating Test (Browne's Method), minutes	12	....
Iodine Jelly Test, minutes	4	....

Air Floated Pitch Standards for Core Sand Binder

Many foundrymen now, instead of using synthetic black core compounds, are using air floated pitch without any further admixture. Your committee begs to present a standard for air floated pitch.

Fineness.—Not less than 70 per cent of any sample taken shall pass through a sieve having 200 meshes per square inch; not less than 80 per cent shall pass through a 150-mesh sieve; not less than 90 per cent shall pass through a 100-mesh sieve; not more than 1 per cent shall fail to pass a 40-mesh sieve. All sieves used shall be made in accordance with the present standards, and sieving shall be performed on the material itself without aid of appliances to increase fineness.

Weight.—The weight per cubic foot shall not exceed 42 pounds. This shall be determined by permitting the pitch to fall as it will into a suitable receptacle, without being compressed.

Volatile Matter.—The percentage of volatile matter in the pitch shall not exceed 56 per cent.

Bonding Strength.—The tensile strength of briquettes tamped to the same density as that found common to ordinary cores, dried for two

hours in an oven having a temperature of 210 degrees Cent., the area of the briquettes being 1 square inch, shall average not less than 200 pounds, with the briquette mixture consisting of 400 parts of new dry silica sand; 48 parts of fire clay; 33 parts of pulverized pitch, and 50 parts of water. All ingredients for the briquette mixture shall be measured by the volumes they occupy when tapped down, but not compressed.

Shipment.—The pitch must be received in a perfectly dry condition, in tight jute bags securely bound with corrugated paper lining.

W. A. Janssen, *Chairman*
A. H. Jamieson
J. G. Galvin
Committee on Steel Foundry Standards.

Discussion

The Chairman, Mr. R. A. Bull.—I notice that no specifications are suggested as to temperature requirements or temperature tests. Some years ago I was associated with a company which had a great deal of trouble securing pitch of suitable quality in the summertime because it caked in the cars during hot weather. After our experience with that condition we drew up specifications of our own for pitch, including a temperature test. I would like to ask the chairman of the committee what his ideas are as to eliminating or including any such specification.

Mr. W. A. Janssen.—I regret that that specification has been eliminated from this report, as it is indeed essential. It is important that some specification be made for the temperature of the melting point.

Some Needs of the Malleable Iron Industry

By W. P. PUTNAM, Detroit

Within the past 10 years manufacturers of malleable iron have awakened to a realization of the necessity of applying more scientific methods in the melting and annealing processes. The gradual change-over from rule-of-thumb methods to exact processes is not yet complete. There are still a number of plants that adhere to the old order, but the chemist, the metallurgist and the mechanical engineer working in close harmony with the foundryman have made many advances in the manufacture of malleable castings. It has taken some hard knocks to bring about these changes. The inroads made by the steel casting industry into the malleable business was the first big alarm which was sounded and it served well to stir the malleable interests to action.

Chemists and metallurgists have been pointing the way by systematic and painstaking methods of melting and annealing, the mechanical and combustion engineers have made many improvements in heating devices both for melting and annealing furnaces, and the foundrymen have steadily improved their equipment until now we have many modern plants producing better castings than ever before.

Work Yet to be Done

In spite of all that has been accomplished there yet remains a number of improvements that must be generally adopted before we can say that we have reached the highest possible standard of excellence.

It is the aim of this paper to point out briefly some of the improvements that still need attention.

First, *Research.* Much good has been accomplished by the research work individuals and groups of individuals have been carrying out in a more or less spasmodic manner. The

work of the American Malleable Castings association has been instrumental in making marked improvements, and yet it has not in the nature of things been able to meet all conditions in such a wide field. It is further desirable that the results of research work be made known to the users as well as the makers of malleable castings. The work to be done on metals will require our combined efforts for many years to come in an endeavor to reach perfect results. Some mooted questions in the malleable iron industry can be enumerated as follows:

1.—What are the exact annealing temperatures that should be used to produce consistently uniform results with any given chemical composition?

2.—What time intervals should be used on all grades of castings for heating up to annealing temperature?

3.—What is the proper time interval at the proper annealing temperature?

4.—What time interval is best under all conditions in the cooling operation?

5.—What are the exact conditions that cause a pearlitic ring in annealed castings?

6.—What chemical compositions will produce the best castings for light, medium and heavy duty?

7.—What is the best type of furnace for melting to produce the greatest strength and ductility in the annealed casting?

8.—Is there a combination of melting and refining operations that will give a better product than is possible with a single type furnace?

9.—What is reasonable to expect by way of increasing the desirable physical properties on malleable castings?

The foregoing are points in the processes of malleable iron production that have already been given a great deal of attention and will still require much elucidation before we have solved the difficulties in the process.

Remarkable Properties

As long ago as 1910 the writer had occasion to inspect a lot of malleable castings that exhibited remarkable physical properties, namely, 21 per cent elongation in 2 inches; reduction in area 15 per cent, and tensile strength 53,000 pounds

per square inch. Today it is not an uncommon occurrence to find malleable castings with a tensile strength of 55,000 pounds per square inch and with an elongation in 2 inches of 12 to 20 per cent. The regrettable feature is that *all* of our malleable castings do not meet these specifications. It is the responsibility of this association to raise the standards until everyone will be obliged to meet what now seems unattainable.

Second, *Equipment.* For many years there has been a crying need for better equipment for the control of annealing and melting operations. Most malleable manufacturers prefer the old air type furnace and for many years this type has proved the best in general use. With the advent of modern metallurgy in which the electric furnace has played such an important role, is it not to be expected that even in the malleable iron industry this type of furnace will assist in the production of better quality castings? An interesting combination of the cupola for melting, the converter for partially decarbonizing and the electric furnace for refining offers a most attractive field for the future development of the industry.

As pointed out in previous paragraphs, much needs to be done to accomplish certain fixed points in the annealing process. After these points have been carefully established by experimentation and careful study they must be regularly carried out in quantity production and this can never be accomplished until the importance of close pyrometric control is recognized by the managers of the plants making malleable iron.

Supervision is Necessary

There are many reliable and accurate pyrometric systems on the market today that are capable of fulfilling every requirement *if given intelligent supervision and the attention necessary* to produce uniform results. The trouble has been and largely is today a lack of appreciation on the part of foundrymen as to what can be done with carefully watched pyrometric control. The pyrometer as it is today is not fool proof. It is valuable in the hands of intelligent supervision but worse than useless if not given proper care. The many ills that have been attributed to pyrometers are too numerous

to mention here. It is hardly fair to expect pyrometers to render accurate records of temperatures if mistreated as they so frequently are. In the opinion of the writer, a first requisite for annealing malleable iron is an adequate pyrometric equipment under the direction of an experienced metallurgist. The equipment and supervision will pay handsome dividends in the shape of uniform product, better quality castings and satisfied customers, to say nothing of lifting the load of uncertainty from the shoulders of the manufacturer.

To accomplish the work outlined in these pages the first step would be to establish a *research foundry* in charge of an experienced foundryman and metallurgist. This foundry should be equipped with all of the various types of melting furnaces and provided with room for the construction of different types of annealing ovens. This work, to be authoritative, should be made the official research department of the American Foundrymen's association and would be a forerunner for research in the steel casting and gray iron industries. The results obtained should be made available by frequent publications.

This may sound visionary to some and yet there could be no undertaking that would prove of more lasting benefit to the foundry industry and the public that uses our product than a well organized and equipped research foundry to study the great variety of perplexing problems that wait a solution. Indeed it seems almost imperative that such a step be taken at this time if we are to hold our own in the great onward march of world development.

Effects of Annealing Gray and Malleable Iron Bars in Copper Oxide Packing

By H. E. Diller, Cleveland

In a research laboratory of one of the large manufacturing companies of the country four men are kept working on purely scientific problems out of which the company does not expect to get any direct financial reward. These men are not delving into abstract questions from any philanthropic motive, but because the company realizes that indirectly the information acquired pays at a satisfactory rate.

So the writer in presenting this paper in which there do not appear to be any facts which are directly applicable to any foundry operation gives it with the hope that indirectly it may be of interest and service.

Some years ago while experiments were being made in annealing malleable iron an interesting phenomenon was discovered. In order to try the effect of a highly oxidizing packing, when used in annealing malleable iron, some bars ½ x 1 x 13 inches long were packed in black oxide of copper and annealed in an experimental furnace.

These bars had the composition of normal unannealed malleable iron, with silicon, 0.80 per cent; sulphur, 0.070 per cent; phosphorus, 0.180 per cent; manganese, 0.25 per cent; and carbon, all of which was in the combined state, 2.70 per cent.

Copper Soaked Through

The temperature of the furnace was raised to 1000 degrees Cent. during the anneal. When the bars were taken from the furnace after the anneal, it was found that the copper oxide was reduced to metallic copper and that it had been melted. The malleable iron bars had been considerably oxidized and when sawed into pieces showed blotches of

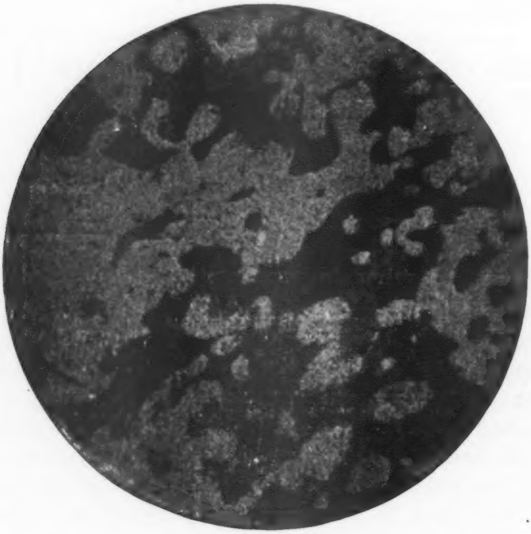

FIG. 1—MICROGRAPH OF MALLEABLE IRON WHICH CONTAINS MORE THAN 20 PER CENT COPPER

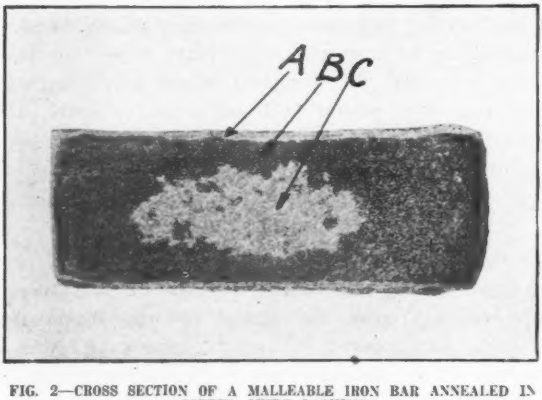

FIG. 2—CROSS SECTION OF A MALLEABLE IRON BAR ANNEALED IN COPPER OXIDE PACKING

copper all through them. Fig. 1 is a micrograph taken at the center of one of the bars. The dark areas are copper. A sample taken by scraping the copper off the edges and then drilling completely through the bar showed 0.67 per cent total carbon and 21.4 per cent copper. A test was pulled

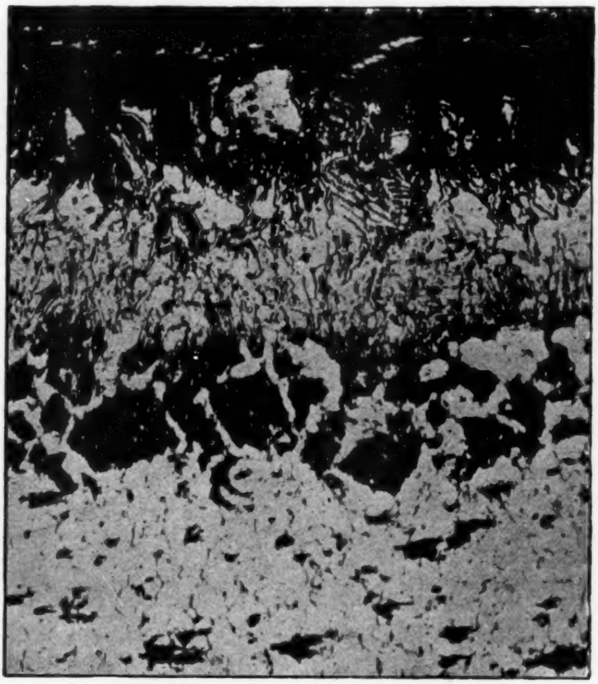

FIG. 3—MICROGRAPH OF OUTSIDE EDGE OF BAR SHOWN IN FIG. 2—NOTE PEARLITE IN THE CENTER

and gave a strength of 68,200 pounds per square inch and an elongation of 1 per cent in 2 inches. It was thought that the high percentage of copper would materially increase the conductivity of the metal but this was proved to be not so by a test which showed the resistivity was 17, which is approximately 10 times that of annealed copper.

Some time after this first experiment other tests were made of a similar nature. In the second trial, however, the test pieces were packed in 3-inch pipes with black copper oxide and the pipes were placed on top of the pots in a regular annealing furnace. The pyrometer in the furnace did not register above 925 degrees Cent. but the copper oxide

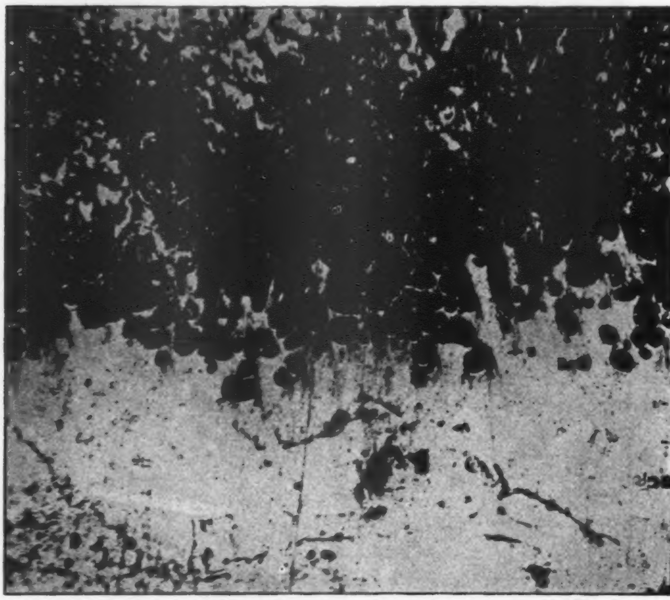

FIG. 4—SHOWS THE DIVIDING LINE BETWEEN *A* AND *B*, FIG. 2

was reduced and the copper fused together, although it had not been completely melted. This together with the fact that the copper was completely melted in the first experiment, when the pyrometer did not register more than 1040 degrees Cent. at any time during the anneal, would indicate that the temperature generated by the action of the liberated oxygen on the iron and carbon had raised the heat inside the tube above that of the surrounding furnace. This seems very probable because the heat of combination of copper and

oxygen is only a fraction of the heat of combination of either carbon or iron with oxygen.

In the second experiment the bars were heated approximately 100 degrees Cent. lower than the temperature reached in the first experiment and the results were somewhat different. When the bars were cut cross-wise at different places

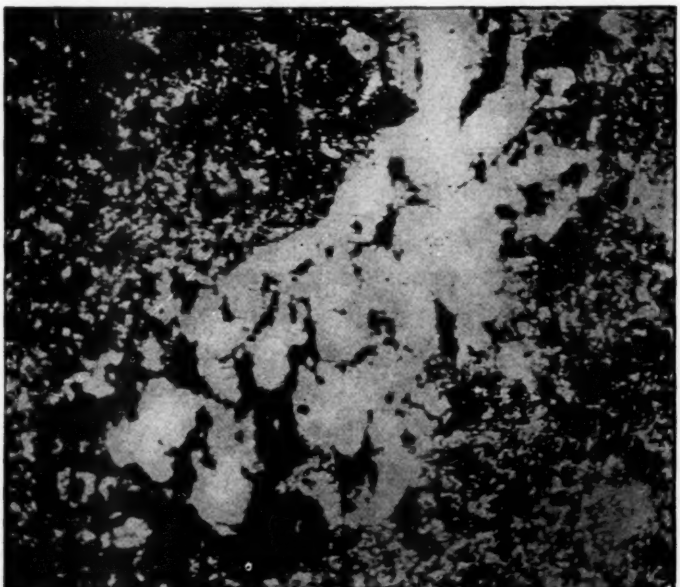

FIG. 5—MICROGRAPH FROM CENTER OF BAR, FIG. 2—NOTE THE LARGE PATCH OF FERRITE

no copper was noticeable except in the center near the middle of the bar, and close to the edge all over the bar.

Fig. 2 shows the cross-section at the middle of a bar. Fig. 3 is a micrograph taken at the outside edge of the cross-section. The dark portion in the upper part is copper. The white at the bottom is ferrite and the dark places toward the center are pearlite. The band of lighter material is a heterogeneous mixture of cementite, pearlite and ferrite. The struc-

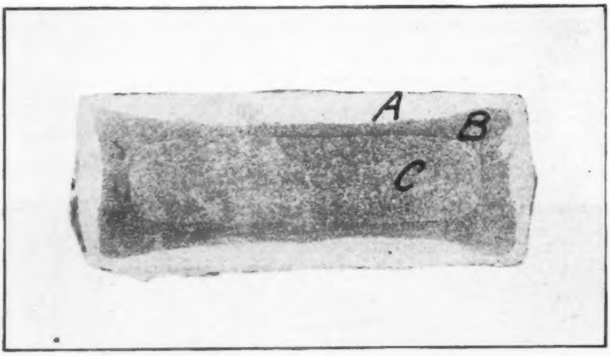

FIG. 6—CROSS-SECTION OF A GRAY IRON BAR ANNEALED IN COPPER OXIDE PACKING

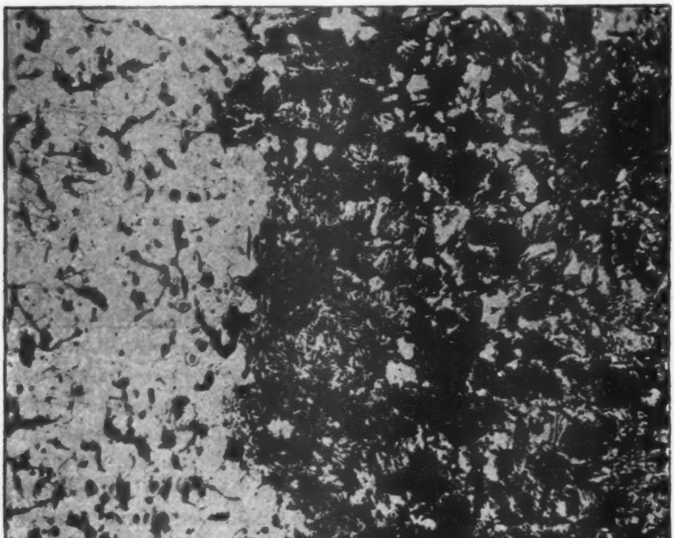

FIG. 7—THIS SHOWS THE LINE BETWEEN *A* AND *B*, FIG 6—DARK PORTIONS CONTAIN COPPER

ture here is more like a complicated high-carbon steel than like malleable iron.

The dividing line between the areas *A* and *B*, Fig. 2, is shown in Fig. 4. The white portion is copper and the dark particles are iron. It can be seen from this micrograph how thoroughly the iron and the copper are knitted together. Some iron particles were distributed through the copper just as some of the copper penetrated into the casting.

The structure of section *B*, Fig. 2, is similar to that usually found in malleable iron. No particles of copper were found in it. In the area *C* just inside of the section *B* there are a large number of small copper areas in a matrix of high carbon steel. In this area occasional patches of white ferrite are found. One of these patches of ferrite is shown in Fig. 5 which also shows the copper scattered through the dark matrix. As the copper color does not show in the illustrations as it did to the eye under the microscope, so the micrographs do not bring out the copper as clearly as a direct view of the sample would do.

Gray Iron Tried

The effect of copper oxide packing on the malleable iron bars created a desire to find out what influence it would have on gray-iron annealed in it. Therefore gray-iron bars the same size as the malleable bars which were treated were packed and annealed in the same way as the malleable bars.

The results were quite different in the case of gray iron than in the case of malleable iron. This is illustrated in Fig. 6 which shows a cross-section of one of the bars. Three distinct areas can be seen. The area *A* contains all of the copper. There is a thin layer of copper on the outside and next to this the copper is very finely divided and is in the form of drop-like areas surrounded by a matrix of iron. This matrix has a peculiar structure and is more like steel than it is like gray iron. The line between *A* and *B*, Fig. 6, is shown in Fig. 7. The dark area is the portion containing the copper. The light portion in the same figure represents the structure of the section marked *B* in Fig. 6. The same structure is seen in the upper section of Fig. 8,

which is part of the dividing line between areas *B* and *C*. This structure is almost like the structure of malleable iron in its appearance under the microscope, but scattered through it can occasionally be seen flakes of graphite.

The center of the bar *C*, Fig. 6, has the structure of unchanged gray iron. This is shown in the lower section of Fig. 8.

FIG. 8—STRUCTURE OF *B* AND *C*, FIG. 6, IS SHOWN—AREA *C* HAS THE CHARACTERISTIC OF GRAY IRON

W. E. Ruder of the research laboratory of the General Electric Co., Schenectady, N. Y., who made the micrographs for this paper, said in regard to the changed structure of the gray-iron bar: "The only explanation which I can give for the peculiar structure shown is that the entire material

up to the dividing line between *A* and *B*, Fig. 6, was in a semimolten condition, and while in this condition the copper oxide became mixed with it and the oxygen was given up by the copper and united with the graphite. The changing of graphitized carbon to temper carbon in section *B* is very unusual and until this experiment I did not think that this change could be brought about short of actual fusion."

Discussion

THE CHAIRMAN, MR. W. R. BEAN.—It seems to me that what Mr. Diller has found may possibly bear some relation to some of the problems involved in the hot galvanizing of malleable castings. We have been conducting experiments for a considerable period of time on that question, which is vital to a great many producers and users of malleable iron. In making very careful tests we have been unable to duplicate the change in quality which results in hot galvanizing malleable iron by quenching, heating and quenching identical specimens for the same temperature. Thus it appears that the change is not one which comes directly or is closely associated with the actual quenching of the part, but that there is some action of the zinc on the metal itself, whether in penetration or in what way it may be. I do not know that it is so; we have not been able to prove it one way or the other.

The Application of Powdered Coal to Malleable Annealing Furnaces

BY CHARLES LONGENECKER, Pittsburgh.

The conservation of fuel is one of the most timely subjects confronting our manufacturers today. Its significance is just beginning to be appreciated. It is a national problem and it is therefore incumbent upon all of us to further the more economical disposition of our fuels. While the underlying motive is the preservation of our resources, fuel conservation will at the same time promote the personal interests of every manufacturer. It is apparent that any reduction in our fuel expenditure has a direct bearing on the cost sheet.

In the malleable iron foundry there are two processes which require for their fulfillment the generation of a large quantity of heat. These are the melting of the pig iron and scrap and the annealing of the castings. The furnace efficiency in both cases is low, and there is thus afforded an opportunity to effect a very considerable reduction in the fuel consumption. This has been accomplished in annealing furnaces using powdered coal as fuel. It is the object of this paper to present some facts dealing with this subject.

Early Installations

There are today some 15 to 20 malleable foundries burning powdered coal in annealing furnaces with satisfactory results.

This fuel was first applied at the plant of the Erie Malleable Co., Erie, Pa. The credit for the success of this installation belongs to B. J. Walker, who in 1896 operated annealing furnaces in which the source of heat was powdered coal. Other companies who appreciated the worth of this fuel and whose installations closely followed that of the Erie Malleable Co. were the International Harvester Co. and the Symington company. A recent installation which it

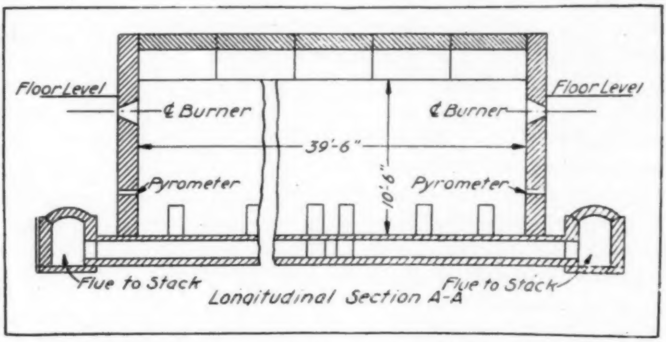

FIG. 1—LONGITUDINAL SECTION ON *A-A*, FIG. 2, THROUGH ANNEALING FURNACE

is the intention of this paper to describe, is that at the Pressed Steel Car Co., formerly the Pennsylvania Malleable Co.

This company made its initial application of powdered coal to annealing furnaces in the fall of 1917, and since then these furnaces have been in continuous operation. In this plant the furnace is practically all below floor level with the roof formed by bungs.

There are 10 large and 18 small furnaces, some of which are used for annealing steel castings. The larger ones have a capacity of 50 tons, while the smaller hold 25

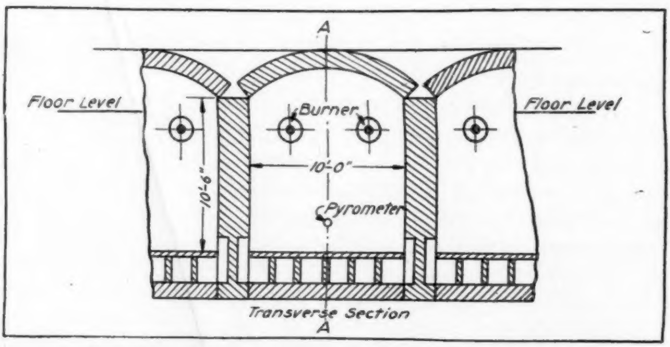

FIG. 2—TRANSVERSE SECTION THROUGH ANNEALING FURNACE

tons. Fig. 1 shows a longitudinal cross section of the large furnace and Fig. 2 a transverse section.

As is well known, the requisites in an annealing furnace from a thermal standpoint are a uniform temperature (and consequently heat) throughout the heating chamber and the maintenance of a constant degree of heat for the proper length of time. To secure these conditions, it was necessary to install four burners in each furnace and maintain a steady flow of coal to these burners. The following table shows a typical run and illustrates how well the conditions demanded have been met:

July			
10	Noon, furnace lighted.		
11	1600° (6 A. M.)	1640° (Noon)	1630° (6 P. M.)
11-12	1620° (9 P. M.)	1620° (Midn't)	1640° (3 A. M.)
12	1640° (6 A. M.)	1620° (Noon)	1620° (6 P. M.)
12-13	1640° (9 P. M.)	1600° (Midn't)	1610° (3 A. M.)
13	1620° (6 A. M.)	1640° (Noon)	1600° (6 P. M.)
13-14	1640° (9 P. M.)	1620° (Midn't)	1630° (3 A. M.)
14	1640° (6 A. M.)	1620° (Noon)	1620° (6 P. M.)
14-15	1640° (9 P. M.)	1630° (Midn't)	1600° (3 A. M.)
15	1620° (6 A. M.)	1620° (Noon)	1640° (6 P. M.)
15-16	1620° (9 P. M.)	1610° (Midn't)	1640° (3 A. M.)
16	1620° (6. A. M.)		

From the foregoing we obtain the following summary:

Furnace lighted, July 10, noon.

Time to bring furnace to temperature 1600 degrees, 18 hours.

Furnace held at temperature, 1600 degrees, 120 hours.

Firing discontinued, 6 a. m., July 16.

Bungs (roof) removed, 6 a. m., July 18.

The castings were then removed as soon as they were cool enough to handle.

A pyrometer is inserted in each end of each furnace. Each one is connected to a central recording instrument. It is the duty of the furnace attendant to read the temperature of each furnace at frequent intervals on this instrument, so that there is little chance for any wide fluctuation in temperature. One attendant supervises all the furnaces.

Time Saved by Powdered Fuel

With powdered coal it requires from 14 to 18 hours to bring the furnace to 1600 degrees, with fuel oil the time is

22 to 24 hours, and with natural gas about 26 hours. From the foregoing it seems apparent that powdered coal gives results which are thermally satisfactory.

There is an accumulation of fine ash which must be removed from these furnaces at intervals. The length of these intervals will depend on the percentage of ash in the coal. When the coal has a low ash content the accumulation is removed once a month. In the standard type of furnace, where the heating chamber floor level is at general floor level, the disposal of the ash is of small moment, due to greater accessibility of both heating chamber and flues.

As is well known, in annealing malleable castings a fluctuating temperature must be avoided and at no time is it permissible to allow the temperature to fall below the critical range. To secure this control of the heat requires close regulation of both the fuel and the air to burn it. No trouble has been encountered in holding these conditions constant.

A comparative record of costs for three fuels is as follows:

Natural gas, 14,000,000 cu. ft., at 35c per 1000..$4900.00
Fuel oil, 105,000 gals. at 8c...................$8400.00
Powdered coal, 525 tons at $5.00 per ton.......$2625.00

The figure $5.00 given as the cost of powdered coal includes besides the coal all labor, power, etc. These costs are taken from actual practice and cover three separate months during each of which one of these fuels was burned.

In another malleable iron foundry where powdered coal is now burned in the annealing furnaces, a saving of 48 per cent has been effected in the quantity of fuel consumed. In this case the amount of powdered coal burned per ton of output is 450 pounds. The time to bring the furnace to temperature has been reduced from 24 to 36 hours required for hand firing, to 11 to 14 hours. When hand fired, there was always a difference in temperature in these furnaces of from 200 to 300 degrees between the front and rear. Today, when fired with powdered coal, this temperature is uniform. This is accounted for by the fact that the pressure in the furnace is equalized as it is impossible to obtain a uniform

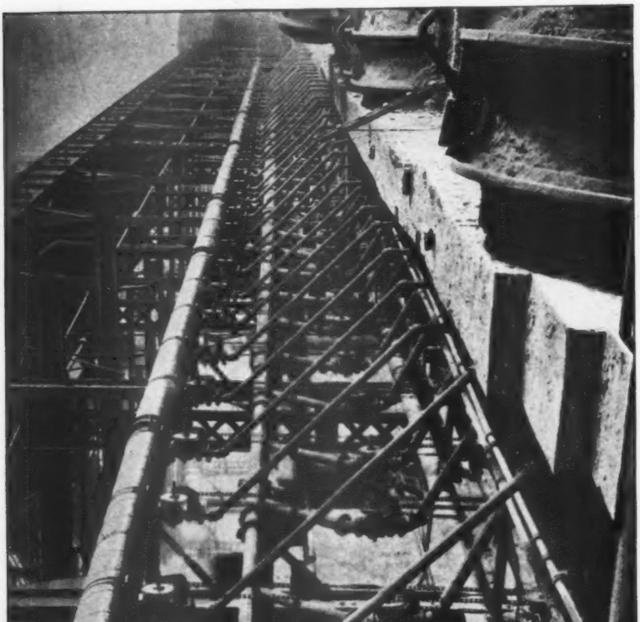

FIG. 3—VIEW ALONG TOPS OF ANNEALING FURNACES

temperature throughout the chamber unless the furnace is under a slight pressure. With stack draft and hand firing it is exceedingly difficult to avoid pulling in some cold air, especially at the door. This makes a cold streak and naturally it is impossible to secure a uniform temperature under such conditions.

Statement of Advantages

The advantages of powdered coal for annealing may be summarized as follows:

First.—A reduction in fuel cost is obtained in comparison with other fuels.

Second.—It is easy to control the feed of coal which corresponds in this respect to gas or oil.

Third.—There is a very considerable saving in labor over hand-fired furnaces.

Fourth.—The supply of coal is more abundant than oil or natural gas.

Besides malleable castings, the Pressed Steel Car Co. also manufactures steel castings. They are annealed in the same furnace as the malleable castings. The temperature carried when annealing steel is 1660 degrees Fahr. One of these furnaces was lighted at 3 p. m., July 15, and firing discontinued at 11 a. m., July 16, so that the total time required for the annealing was 20 hours. The coal consumption was 140 pounds per ton of metal.

Fig. 3 shows the tops of the furnaces and the pipes through which the coal and air are delivered to the burners. The large spiral riveted pipe on top carries the coal, while the secondary air flows through the lower one. From both these branch 2-inch wrought iron pipes. The latter are connected at their upper ends to the control valves, shown in the illustration, which regulate the flow of coal and air to the burners. Their lower ends terminate at the burner.

Principle of Distribution

The coal which passes through the upper pipe is of course very fine, as it must be held in suspension throughout the length of the pipe. The principle of distribution is as follows:

The coal is received in cars and after being dried is pulverized and then conveyed pneumatically to a substation at the foundry building. Here it is separated from the high pressure air and falls into a 25-ton bin. Two spiral screws feed the coal from this bin into a pipe connected to the suction side of fan. This fan has a capacity of 6000 cubic feet of air per minute. In the fan the fine coal is mixed with air in the proportion of 1 pound of coal to 60 cubic feet of air. This mixture is then forced through the pipes and delivered to the burners as desired by the furnace attendant. As is well known, it requires at least 200 cubic feet of air to form a combustible mixture with one pound of coal.

There is, therefore, no danger of combustion until the necessary additional 140 cubic feet has been added at the burner. The ratio of 1 pound of coal to 60 cubic feet of air is maintained automatically by a very simple electrical contrivance. If desired, the ratio can be changed and the machinery set to hold it constant.

There have been spasmodic attempts to apply powdered coal to air furnaces, but none of these have progressed beyond the experimental stage. I believe there is a very profitable field open in this connection and from what information I can gather I do not see any insurmountable obstacles to its successful application. W. R. Bean presented a paper on this subject at the Boston meeting. The results from the experiments cited in this paper substantiate the opinion that we will before long be burning powdered coal in melting furnaces.

A movement is now on foot, I believe, to standardize and improve malleable iron annealing furnace construction. This certainly is a laudable movement, and if carried through should insure beside a high quality of product an increased efficiency of operation. It should lower the quantity and cost of fuel per unit of output. Those behind this movement will find powdered coal admirably suited to fulfill the fuel requirements in these furnaces.

For the information contained in this paper, I desire to extend my thanks to C. H. Gale, superintendent of the foundry of the Pressed Steel Car Co.

Efficient Use of Pulverized Coal in Malleable Foundry Practice

By Milton W. Arrowood, Chicago

There is probably no branch of industry that can realize greater benefit from the proper application of pulverized fuel than the malleable iron foundry. The economy in annealing ovens is very considerable and has been recognized for a number of years. The advantage of any efficient means of eliminating hand firing on air melting furnaces, is a matter that is hardly open to debate with any foundry superintendent. It is of interest, therefore, to examine the elements of the matter, considering the difficulties, in order to reach a rational conclusion as to what means may be employed to utilize pulverized fuel in annealing ovens and on melting furnaces, with maximum efficiency and satisfactory working conditions.

Preparation of the Fuel

It will not be the purpose of this paper to discuss in any detail the general processes of preparing coal for use in pulverized form, as it will be assumed that the coal has been properly prepared and brought to the furnace in proper condition and of approximately the recognized commercial standard of fineness such that 85 per cent will pass through a 200-mesh screen. Notwithstanding the claims that have been made, from time to time, that it is not necessary to grind the coal to such a degree of fineness, the weight of experience seems to indicate that best results are secured with finely-ground fuel. Let us take it for granted, therefore, that suitable receiving, crushing, drying, pulverizing, distributing and storing facilities have been provided to furnish fine, dry fuel at the furnaces. To accomplish this, with a clean plant and elimination of hazards, it will have been necessary to have designed the plant with great care;

not only with a view to complete removal of moisture, so that the coal may be most readily pulverized, but also with a view to maintaining the dry condition of the fuel until it is used.

The standard of dryness necessary will vary somewhat with the character of the fuel, depending on whether the moisture present is surface or combined. While it is generally advisable to dry the coal to 1 per cent or less of moisture and the coal so prepared will always show the best furnace conditions, there still may be times, particularly during the winter season, when absolute maintenance of such a rigid standard is not possible. The degree of efficiency then possible will depend much on the size and type of furnace and still more on the type of feeding apparatus employed. While early failures with pulverized fuel were attributed largely to moist, coarse coal, it has recently been claimed by some that it is not necessary to dry the coal. From a thermal standpoint, this could never be the case, for if "low-temperature" heat is not used to remove the moisture in a dryer, "high-temperature" (more expensive) heat must be used in the furnace to remove and perhaps disassociate this moisture. If the coal comes from a dry mine containing 2 or 3 per cent of moisture, or even more with certain coals, and is kept under cover, it is doubtful if the overhead for drying equipment can be justified from the standpoint of furnace loss, except in the more difficult high-temperature or close temperature-control processes. This and similar matters can only be determined by close consideration of all the facts in view, and by bringing into play the trained judgment of experienced and competent pulverized fuel engineers.

Furnace Efficiency

A great deal of thought has been expended on what may be called the preparation and distribution side of pulverized coal installations, but a casual survey of a half dozen of the latest and largest installations is sufficient to leave one amazed at the comparatively little regard apparently given to the important matter of actual results with the pulverized coal

in the furnace. This fundamental seems generally to have been left for the plant operating force to work out. The prevailing attitude seems to be embodied in the oft-quoted question and answer: "Will powdered coal burn? Certainly it will burn. Throw it into the furnace and let it burn." Put this way, it has seemed so easy as to appear an actual bonanza for the uninitiated. But soon, ah! soon comes the disillusionment. Then we have the old saw, "We tried powdered coal and did not find it practical for our furnaces." Here we have the answer to the question, "Why has

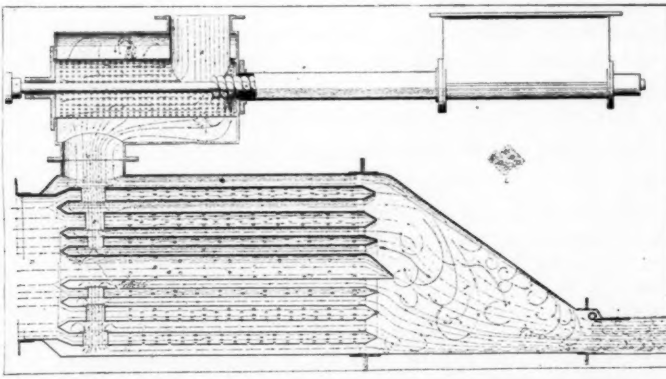

FIG. 1—DIAGRAM SHOWING MIXING ACTION IN PULVERIZED COAL BURNER

powdered coal not advanced more rapidly? Why is it not used for this, that or the other thing? Simply because the seeming ease of application has caused (shall we say it?) "Fools to rush in where angels fear to tread."

Of course volatile pulverized fuel is highly combustible when dry, and if injected into a furnace at ignition temperature, will ultimately burn as it finds air. But how will it burn? Where will combustion be completed? What kind of slag will be formed and where will it be deposited? What will happen to the bridge wall, the roof, the side walls, the flue outlet? It is not believed that the highest efficiency is possible except where the greatest care is taken to introduce the air and fuel into the furnace as a completely diffused

mixture. This paper, then, is a protest against "haphazard feeding," "large combustion space required for pulverized coal," and methods other than complete mixing of the air and fuel *outside the furnace.*

Many references are made in current pulverized coal literature to the necessity of mixing the fuel with air. The term "mixing" is applied apparently to any scheme of feeding pulverized coal that will result in one or more moving strata of coal and air streams, some of which may be arranged to cross-fire on the others and thus create a certain "commingling effect." This is not at all the character of mixing required for that complete diffusion of the coal dust in the total amount of combustion air by which means alone the highest efficiency can be obtained. Let us therefore look at the matter from a common sense standpoint. There are certain propositions on which it is believed we all may well agree. Some of these may be stated briefly as follows:

1.—Combustion is a chemical reaction, which in practice is employed—not for any effect of the reaction itself—but in order to liberate heat, a by-product of the reaction. Since it is heat that is to be used, and this heat is present in the gases resulting from combustion, the less foreign matter, slag or ash, contained in the gases, the more efficiently can the heat be utilized. Hence a burner that quickly and largely removes slag from the gases is desirable.

2.—Any air not required to supply oxygen for combustion is a detriment, since it will absorb heat. Arguments of "expediency" calling for the use of excess air to protect brick, boilers, etc., from excess temperature, should therefore be abandoned in favor of apparatus and methods that control the heat without dilution.

3.—From the earliest inception of chemistry, the idea of molecular formation has been at the base of chemical science. It is well recognized that a rapid and complete reaction is best produced by fine division and thorough mixing of materials, which then need be present only in the chemical proportions necessary for the reaction. Therefore, any plan of feeding pulverized coal calling for an excess of air, must concede coarse coal or poor mixing—one or both. There follow all the secondary difficulties, such as reduced temperatures, imperfect control of furnace conditions, progressive com-

bustion, abrasion of brickwork, slag deposition on work and a train of other problems.

4.—Complete mixing or diffusing of gases one with another is conceded to be one of the most difficult problems of the scientific investigator. Any process which introduces separate air and coal streams into the furnace, to be there mingled and broken up, prior to completing combustion comes immediately in contact with this physical difficulty of gas mixing. It is not then a simple process of diffusing finely divided solid material through the air, but the far more

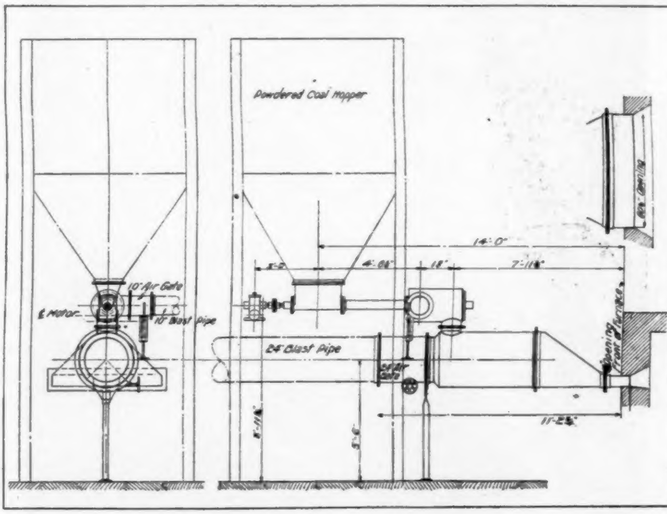

FIG. 2—GENERAL ASSEMBLY OF BURNER FOR AIR MELTING FURNACE

complicated matter of thoroughly mixing and diffusing one with the other, the oxygen and various gases of distillation from the coal. Moreover the furnace temperature is such as to increase the volume of gases until it is several times greater than that of the cold air, which might better have been mixed with the fuel outside the furnace in an apparatus designed for the purpose.

5.—A review of inventions of pulverized fuel feeders and burners, shows that in practically all cases, the effort has been to attack a body of coal dust from without by

FIG. 3—FRONT VIEW OF MELTING FURNACE AT ERIE, PA., SHOWING BURNER INSTALLED COMPLETE

means of variously directed jets or drafts of air or else to deposit a stream of coal in a moving stream of air. In some cases a specially constructed injection nozzle discharges a stream of coal in an annular stream of air, or it may be that an annular stream of coal is discharged around an inner jet of air. Any method of breaking up or eroding a body of coal by a stream of air flowing over the surface, will require both time and a considerable amount of excess air. Again, where the coal is deposited in a moving stream of air, either this air must move at comparatively high velocity, in order to carry the comparatively dense body of dust until broken up, or else a volume of air in excess of combustion requirements must be used. Either horn of high velocity or excess air is objectionable.

Like Breaking a Grenade

It appears safe to state that none of the "streamline" methods of feeding are capable of completely diffusing the coal dust uniformly throughout the entire volume of combustion air, or of accurately proportioning the amount of air to coal in a strict combustion mixture. Such a complete mixture can be had in an apparatus, designed especially for the purpose, wherein the volumes of coal and air are successively divided into various smaller volumes, and so handled as to create a large number of eddying currents of air within the apparatus, sufficient in number and strength of action to bring about complete diffusion of the dust particles within the air. All problems calling for rapid and wide diffusion, whether it be a bursting hand grenade, or the mere breaking up of a dust body, call for action from the inside out. On this principle an apparatus can be designed to diffuse a sufficient volume of dust to meet the large capacity and exacting requirements of the largest furnaces, calling for low discharge velocity and accurate control of combustion conditions. Our ideal condition, then, will be to conduct a certain amount of air within a volume of coal dust, and by there turning it loose, burst the particles apart in all directions. Then by subjecting this rough mixture to further treatment in an apparatus, creating a large number of eddying currents, we insure uniformity of dust diffusion throughout the entire volume of combustion air.

The first phase of this ideal process can be only approximated in practice, but the action of the coal control, the upper part of the apparatus seen in Fig. 1, approximates the desired condition sufficiently for all practical purposes. Here the coal dust as thrown off by the feed screw into the mixing drum of the coal control, is immediately attacked by a heavy blast of air, *A*, directed at right angles across its path and finding

FIG. 4—VIEW OF BURNER AND FAN DRIVE

a ready entrance into the body of coal, owing to its disturbed condition as showered from the screw end. The coal and air must then pass through the holes of the perforated screen in the drum, and in so doing there is a kind of kneading or wire-drawing effect, tending to equalize the dust diffusion in the air. The jets issuing from the screen holes, *B*, flare, and on coming in contact with the outer drum, burst into reverse

flow lines somewhat on the order of a mushroom head. The distance between shell and drum being small there is opportunity for a rebound of the current against the outside of the perforated shell, if indeed the flow lines have not at this time been lost in the mass of eddying currents, all of which are ultimately drawn together at the one large outlet, *C*, there to receive a general kneading to make diffusion more uniform. The action here may be taken as rather complete, but as we wish to work on accurately proportioned mixtures of air and coal, the diffusion must be still further carried out in the discharge section of the apparatus, which is the mixing chamber proper.

Detail of Burner

The partially mixed material coming from the coal control enters the burner at *C*, Fig. 1, which shows what is known as a quadruplex burner, so called on account of its having four sets of mixing shells concentrically arranged. This burner, which is 30 inches in diameter and about 10 feet long over all, is of the size and type generally used for the air melting furnace. The design is capable of being used with any number of the mixing shells and in the smaller sizes one or two sets are usually employed. On the average malleable annealing oven, for example, two sets of shells will ordinarily be employed and the outside diameter of the burner will be from 6 to 10 inches and the overall length from 3 to 4 feet. Fig. 2 shows a general assembly of the apparatus in front of a melting furnace.

Fig. 3 is a general view of the front end of this furnace, showing the coal hopper to the bottom of which is attached the coal control, containing the feed screw which delivers the coal to the control mixing drum seen at the left behind the post. Below is the burner proper with its discharge nozzle, which is 6 inches high and 5 feet wide. The blast fan is mounted immediately at the right of the short outlet connection which connects it with the 24-inch valve and hence to the burner. It is here shown driven by belt, though direct-connection will later be installed, being considered preferable for this drive. The general assembly of this apparatus is most clearly

shown, with some of the principal dimensions in the vertical elevations, Fig. 2, where the position of the valves and speed reduction set for the direct-connected drive of the feed screw are also shown. This view is on the side opposite from that of Fig. 3. Fig. 4, which is another view taken farther to the right, clearly shows the motor and gear reduction set of the feed screw drive. This view also clearly shows the arrangement of the fan and its motor and the controllers which are immediately to the rear of this motor beside the fan are more clearly seen in Fig. 5, while Fig. 9 gives a good idea of the arrangement for top blast as provided from a direct motor-driven, positive-pressure blower. This unit has considerably more capacity than is actually required, but was installed to avoid delay in erection on account of being on hand. At the right of Fig. 9, it will be noted that provision is made to remove a bung of narrow width in order to check the stack draft as required, the stack provided being of rather more liberal proportions than necessary with this method of firing.

Referring again to Fig. 1 in which an attempt is made to indicate the general tendency to formation of air currents, it will be noted that the partially mixed air and coal on coming from the coal control and entering the burner at the point *C* is divided by means of the successive communicating tubes, *E*. This mixture enters each of the four coal and air (*C*-and-*A*) strata, while at the same time additional air in an amount regulated to give a perfectly balanced mixture, enters the open end of the burner through a 24-inch valve. Some of this air passes into the center pipe, while the remainder goes into the air strata which are concentric and just inside their respective *C*-and-*A* strata. The outer shells of all air strata and the inner pipe contain a number of holes arranged in successive staggered rows, a total of 1516 holes being used in all the shells of the 30-inch burner. It will be seen that these 1516 jets of air give a tremendous mixing effect in the comparatively thin strata of partially mixed coal and air streams. At this point it will be discovered that, aside from the space economy in having the shells arranged concentrically, there is a purpose in having the radial distance between the shells comparatively short, in

order to insure a good jet-piercing effect into the resilient *C*-and-*A* strata of material. The analogy here is that of cutting a thick piece of rubber with a knife. One's first instinct is to place the rubber on a hard surface. With usual fan blast, the air jet will pierce little more than 2 inches, so at this distance a solid backing is provided.

Eddy Currents are Useful

Consideration will show that the structure illustrated will cause a large number of complicated, cross-firing and eddying

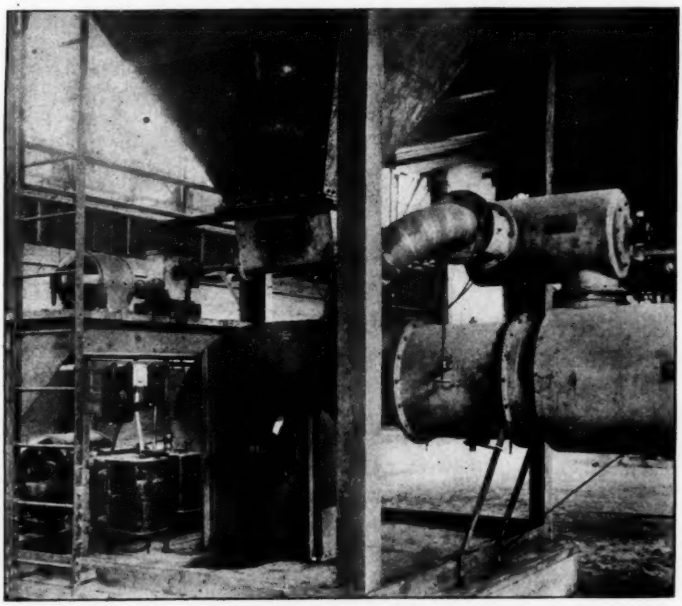

FIG. 5—OPERATING SIDE OF BURNER SHOWING LOCATION CONTROLS

air currents, thus affording every practical assurance of the thorough and complete mixing—*diffusion*—of the coal dust in the entire volume of air. In the first place it is noted that the partially mixed material, on entering the various strata of the burner, is considerably expanded, by reason of the fact

that the volumetric capacity of the burner is calculated on the total amount of air to be used, while a small proportion of this air, usually from one-fourth to one-eighth, is introduced into the coal control. The exact division of air is not of the first importance, provided that sufficient air is admitted to the coal control to give the general breaking up effect desired. Since the greatest mixing effect occurs in the burner proper, it is evident that the larger proportion of air can be used there to best advantage.

In any case, therefore, the rough mixture from the coal control will find considerable expansion volume on entering the *C*-and-*A* strata of the burner. On this account and also on account of some loss of pressure due to friction in the upper part of apparatus, the pressure in the *C*-and-*A* strata will be considerably less than that in the air strata. The rough mixture is then in the condition of expanding or opening up at the same time that the 1516 spreading air jets are feeding into its rarer atmosphere. Any process of attempting to drive air jets from without into a cylindrical moving stream of air loses all sight of this expansion effect in mixing and moreover tends to make piercing by the jet more difficult owing to its compressing the stream into which it endeavors to flow.

Some attempt is made to indicate the currents by arrows and flow lines on the diagram, Fig. 1. The annular streams of completed mixture issuing from the *C*-and-*A* strata into the nozzle are deflected down by its sloping roof into and across each other, until on reaching the bottom of the nozzle they would tend to flow in a reverse direction but for the stronger driving power of the stream as a whole. Thus numerous eddying currents are formed in the nozzle and the mixture is kept in violent agitation until the moment of discharge into the furnace as a rolling, eddying mass of air currents uniformly charged with dust. This internal rolling and whirling effect in the material as discharged is of the greatest value in securing rapid ignition by bringing the inner portions of the mass—especially in the larger burners—in contact with the outer igniting film of mixture. Right here it is well to note what possibly may explain the fact that even with comparatively large nozzles

and low discharge velocities, this burner shows no tendency to back fire. Very probably this is due in some degree to the eddying currents tending to damp or break up any incipient flame current propagation in a direction toward the burner. This is considered a valuable feature, since it permits the low velocity of discharge so essential to best results, and particularly so in the large burners.

The elongated rectangular nozzle also appears to have a certain damping effect against back firing, particularly in the smaller sizes. Early in the experimental work with burners of this design, it was discovered that the discharge velocities could be reduced to a point much lower than had previously been considered possible.

Having thus developed a burner design capable of being constructed in any size and which is capable of intimately mixing and diffusing the coal dust throughout the entire volume of air admitted to the apparatus, and to which air is admitted under control, so that it can be regulated to the theoretical amount required for complete combustion; it remains only to consider the benefits derived in the furnace from such a mixing and feeding apparatus properly proportioned to give the volume and velocity of discharged mixture suited to the particular furnace. As the conditions named, give a wide degree of flexibility in operation, no hesitancy is felt in applying this burner to any type of furnace.

General Furnace Conditions

Before taking up in detail the conditions in melting and annealing malleable iron, it seems well to point out some of the general furnace conditions established by the operation of this burner. Owing to the low discharge velocity, it was soon found that the mechanical erosion and abrasion of brick was eliminated. Owing to the mixture entering the ignition chamber completely diffused, with each particle of coal surrounded by sufficient air for its combustion, there is no necessity of impacting the stream of fuel and air against the bridge wall, with the idea of breaking up and commingling the streams of material and air heretofore injected into the furnace largely as parallel unmixed streams. This saving of brickwork and also

the complete combustion resulting from mixing—no combustible in ash—reduces the amount of slag formed in the furnace.

Thus the slag to be considered is practically only that resulting from the fusible material in the ash of the coal. It is well understood that any process of commingling the jets of air and coal inside the furnace, means that combustion will occur throughout the length of gas travel *as the coal particles find air,* so that there is established a condition which we shall term progressive combustion. With this character of combustion, the heat is liberated progressively along the path of flame travel and at no point is there a comparatively high heat center. Without going into chemical details—and I am not a chemist—it is understood that in a general way, comparatively low flame temperatures of say 1600 to 2000 degrees, result in

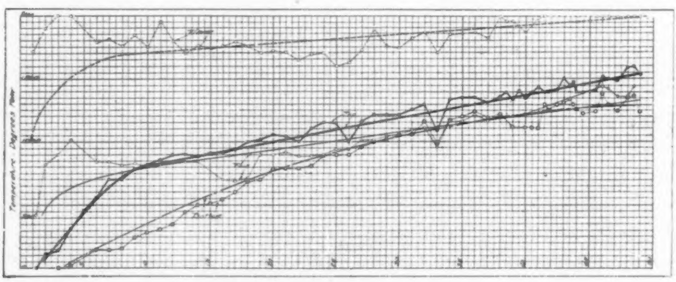

FIG. 6—TEMPERATURE RECORD ON MUFFLE ANNEALING OVEN

the formation of the lower oxides of materials contained in the ash that are fusible. It so happens that these oxides are stiff and pasty and difficult to handle when hot, and when cold are extremely hard and difficult to break out of the furnace. On the other hand these same materials in the ash when fused at a higher temperature (materials such as lime, iron, silica and to some extent magnesia) will then form the higher oxides, which are highly fluid when hot and brittle as glass when cold. Any material which does not fuse at usual temperatures of say 2500 to 3000 degrees, such as aluminum oxide, for example, will pass over as an impalpable fine powder.

Now with progressive combustion there is not sufficient heat liberated at any one point to establish the temperatures

necessary for formation of the desirable kind of slag. The sticky plastic slag that is formed includes within its body by agglomeration a percentage of infusible material, thus increasing the amount of this slag to be handled. One of the difficulties in locomotive and boiler practice has been the honeycomb built up on tubes by this slag formation. It seems reasonable to assume that, when cutting down a charge of metal, such a slag formation on the iron surface might readily be formed, with a burner resulting in imperfect mixing and hence progressive combustion. It can readily be seen that such a heavy layer of slag could be collected more easily on a mass of cold metal than on comparatively hot tube sheets, as in a locomotive. Such a formation could not be disposed of until the general temperature of the furnace had risen high enough to fuse it as a body. This would mean too long a time in cutting down the charge.

Where the air and coal mixture is introduced into the furnace, with each particle of coal surrounded by its appropriate amount of air for combustion, the burning of this particle occurs almost instantaneously on its being subjected to the ignition temperature. Since upward of five thousand times as much volume of air as of coal, is required for complete combustion; it is more a question of heating the air volume, than the coal particle itself, to the ignition temperature. The discharging stream should therefore be of form to present the greatest practicable area of contact surface for ignition. This is an additional reason for the elongated rectangular form of nozzle, which affords a larger surface of ignition contact for the issuing stream than would be the case with a circular nozzle, having the same cross-sectional area. In cases where it may be desired to somewhat retard combustion, as perhaps in cement practice, a circular nozzle may be used.

Triangle of Igniting Material

Referring to Fig. 7, it will be seen that, as the mixture comes forth from the nozzle, the outer film is immediately ignited and the central portion of the stream moves forward thus exposing an additional surface for ignition. This continues, to form the triangle of igniting material as seen in the

drawing, ignition being complete at the point of this triangle, which corresponds to the tip of the bunsen burner. In this sectional elevation of the flame formation, the inner triangular portion represents material to be ignited and the lighter lines represent in general the flame formation, which is elliptical except as restricted by the confining walls of the furnace. This is as would be expected, owing to the increasing volume of gas from successively ignited surfaces and natural expansion of the gases. In smaller burners, with comparatively thin discharging streams of mixture, the central triangular portion of the figure practically disappears and the entire discharge seems to ignite from the burner, especially when the furnace is hot. With the 30-inch burner on the melting furnace and its nozzle 6 x 60 inches, this central pointed portion of igniting material may be 3 to 4 feet long when the furnace is cold, but it also practically disappears when the furnace has become hot. The combustion chamber should therefore be long enough to accommodate this burning jet and allow reasonable expansion of the flame produced before reaching the bridge wall, as otherwise the flame will be chilled too much and will make the furnace sluggish in firing up. In practice it is found that little if any change need be made in the usual length of combustion chamber, but the volume should be reduced to correspond with the less volume of gases being handled with a balanced mixture. This is best done by building the floor of the combustion chamber only a few inches below the top of the bridge wall, the bottom of burner nozzle being usually set in line with the top of the wall. The burner so erected is capable of feeding, mixing and burning from 1000 to 3000 pounds of coal per hour when supplied with blast air at a pressure of 2 to 3 ounces and with a pressure of 5 ounces it may feed as much as 5000 pounds per hour.

In current literature, discussing powdered coal problems, it is common to see statements to the effect that exceptionally large combustion space and strong stack draft are required. Such statements seem to concede that the feeding and mixing apparatus is deficient. Our existing ideas on the space required with stoker and hand firing, are determined by the necessity of ample space for commingling the burning gases, resulting from progressive combustion, as air is passed over the outer burning

surfaces of the fuel lumps. Also the combustion space must take into account the inevitable excess of air that is required to secure any sufficient volume of air in actual contact with the coal. Stack draft is determined, other considerations aside, from the necessity of drawing this large volume of combustion and excess air through the fuel bed. With pulverized coal, this requirement for stack draft is eliminated and if a burner is such as to require more commingling space than with the

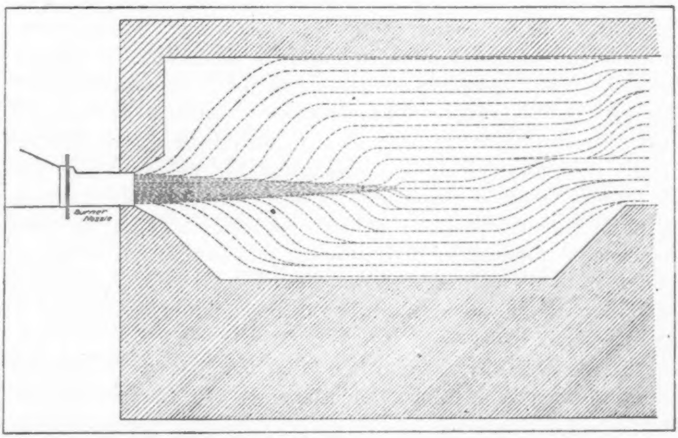

FIG. 7—DIAGRAM OF FLAME IGNITION AND FORMATION

old methods of burning lump coal, it is evidently a most inefficient piece of apparatus. After all is said and done, why should we spend money to pulverize the coal to the ultimate practical commercial degree of fineness, if we propose to use a feeding apparatus that will feed masses of the fine particles into the furnace as a body? If several thousand particles are to be thrown into the furnace as a lump, we may as well save the cost of grinding that lump.

A Confession of Inefficiency

Again the statement that excess air must be used in burning powdered coal, is on its face a confession of inefficiency in the feeding and mixing apparatus. The opinion seems to be

that some excess air is required particularly in boiler applications and more or less in general heating furnaces, in order to avoid a destructive temperature on the brickwork or tubes. In malleable practice, we are concerned only with the brickwork and, referring again to Fig. 7, it will be observed that the center of heat must be at or near the tip of the ignition body, or the center of the flame production. All combustion is in suspension in the body of gas and the high combustion temperatures of burning particles of carbon, hydrogen, etc., are formed in the center of the gas volume. Thus the brickwork in the surrounding walls of the furnace comes in contact with the lowest temperature gases—the outer expanded film of gas—in the furnace. This balanced condition of internal high temperature in the body of gas causing uniform expansion in all directions, is readily maintained by reason of the low discharge velocity employed. Otherwise the hot burning material would be thrown against the bridge wall at the very moment of combustion and thus cut it away as has been experienced with high-pressure jet feeders. It is a remarkable fact that the interior walls take on a glaze and show practically no signs of erosion.

It seems hardly necessary to point out that such a method of controlling temperature and flame is far superior to any method of introducing excess air to chill the gases—usually burning in contact with the brick work—in order to save the furnace lining. The older method of injecting a high-speed jet of material into the furnace and against the bridge wall, means that the wall is cut away and the flame curls upward and to the sides, thus cutting out both roof and side walls. The action is mechanical and also, due to the high temperatures of combustion—with carbon perhaps 1000 and with hydrogen 2000 degrees above furnace average temperature—the limit of brick endurance is passed and of course the brick gives out. Evidently this high temperature must be removed from the brick, but is the injection of cold air on the surface of the brick the right method?

A natural assumption would be that the length of combustion chamber and the volume of discharge should be arranged so as to have this combustion occur in contact with the charge

of iron in a melting furnace, thereby securing a rapid cutting down. There is, however, a great difference between burning the material in contact with a hot refractory substance and burning it in contact with the cold iron which it is desired to cut down. The chilling effect of the iron on the flame is such that heating is much retarded and the time of melting would be increased. Furthermore the greatest heat would be at the back end of the charge.

Tests

Having developed this type of apparatus, arrangements were made to conduct a series of tests on an air melting furnace at a plant at Meadville, Pa. Owing to some misunderstanding as to the method to be used in controlling the top blast, the original burner installed was designed to admit half the air at the top blast and take the remainder through the burner. This sacrificed at least half the mixing efficiency of the apparatus. A 14-inch duplex burner was used, capable of taking air enough for mixing and burning 1200 to 1500 pounds of coal per hour and a proportionately greater amount according to the amount of air admitted at the top blast. Pulverized coal was purchased from an outside plant, being that used ordinarily for annealing. It analyzed as follows:

	Per Cent
Sulphur	1.34
Volatile matter	35.32
Fixed carbon	50.80
Ash	12.45
Moisture	1.43

Owing to the fact that the coal was stored in paper bags in an open foundry and samples were taken from the bags, it is believed a considerable amount of the coal contained more moisture than shown, as many of the bags were broken. The coal had been in this storage for some six months before the test.

Air was supplied by a No. 7 Sturtevant fan at a pressure on the fan outlet of five ounces, the line running some 40 feet to a Y-division supplying the two parts of the burner. The existing branch of the line supplying air to the ash pit was not disturbed. The burner was first lit with the furnace empty, the total air pressure at the burner being 8 inches and at the over-

head blast pipe 4.25 ounces (difference due to pipe layout). The furnace was operated on this basis for two hours 12 minutes, the average coal fed being about one ton per hour.

At 1 hour and 20 minutes from starting time, a pig of iron was placed in the rear side door of the furnace and another in the front door. These were dripping freely in eight minutes. When feeding the full amount of coal, combustion was not complete until the flame came in contact with the top blast just over the bridge wall. Thus the principal heat zone was too far in the rear of the furnace. Coal was filled into the hopper by hand from bags of weights averaged, the amount of coal left at end of run being deducted. It was found that the feed screw had been delivering 0.3 pound

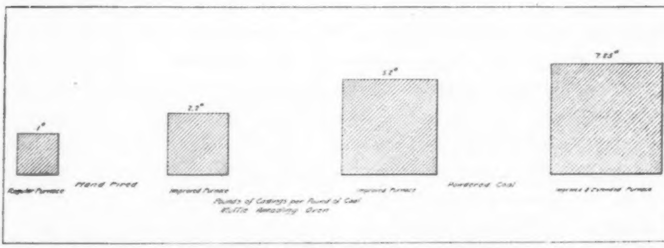

FIG. 8—DIAGRAM SHOWING COMPARATIVE ECONOMY OF PULVERIZED COAL BURNERS AND HAND FIRING ON ANNEALING OVEN

per turn. The furnace was built for a charge of 10 to 12 tons.

The following day, a 2-ton charge made up of pig iron, hard scrap and railway malleable, showing an average of 0.914 per cent silicon and 0.627 per cent manganese was put in the furnace, which was then fired, without skimming bath, for 3 hours and 29 minutes, when the iron was poured, the fire being continued for 15 minutes while tapping out. A total of 5914 pounds of coal were used, or say three tons of coal for two tons of iron. The general character of the metal was satisfactory but it was necessary to leave considerable of slag in the furnace, owing to the condition of the bottom and the tap holes.

The brick covering that had been placed over the grates was removed at the bridge wall across the fire box for a

space 1 foot wide lengthwise of the furnace. This made it possible to admit air through the ash pit under the fire in regulated amount. A 4-ton charge showing 0.902 per cent silicon and 0.62 per cent manganese was charged on the following day and on starting the fire it was at once seen that the large volume of air rising at the bridge wall deflected the flame to the roof and formed a cold blanket on the bath, thus making a slow heating furnace. The rear bridge wall had been built up two courses of brick and after running one and a half hours it was decided the fire was choked too much. Twelve minutes were lost in removing some of the brick, after which the fire was continued for a total of 5 hours and 52 minutes, including a short shut down to replace bung. The roof showed distress while the bath showed dull, attributed to the air condition above mentioned. Owing to the short charge it was not possible to skim the heat effectively, although it was partially skimmed after four hours. The total coal consumption was 10,300 pounds or 5.1 tons for four tons of iron melted in a 12-ton furnace. A test bar poured at 4 hours and 40 minutes showed silicon, 0.54 per cent, sulphur 0.102 per cent, phosphorous, 0.131 per cent, and combined carbon 3.50 per cent.

Changes Were Made

The opening over the grates was filled up and the eight 2-inch tuyeres on top blast were changed to 3-inch, the floor of combustion chamber was filled up to within 10 inches of top of front bridge wall. The outer end of the burner was raised and the discharge pointed at a downward angle against the front end of the charge. The burner was then lighted on the empty furnace for 1 hour and 15 minutes, it being desired to start a charge with a hot furnace. A 5-ton charge of the same composition as the previous heat was then fired for 4 hours and 55 minutes, with shut down of 5 minutes on account of the loss of a bung. The total coal fed was 9088 pounds or an average of 1725 pounds per hour, or a total of 4.5 tons for 5 tons of iron in a 12-ton furnace, with a considerable amount of slag left in the furnace from previous heats that could not be skimmed properly. The

quantity of metal was sufficient to permit fair skimming and at 3 hours and 30 minutes a considerable amount of slag of good appearance was skimmed off. At 4 hours and 10 minutes a test bar showed 0.73 per cent silicon and 0.968 per cent sulphur, while a second bar poured at tapping out 4 hours and 40 minutes from starting showed as follows:

	Per Cent
Total carbon	3.20
Combined carbon	2.78
Graphitic carbon	0.42
Manganese	0.30
Phosphorous	0.155
Silicon	0.98
Sulphur	0.06

A test bar poured from a ladle taken off during tapping out showed 0.68 per cent silicon, 0.081 per cent sulphur and a tensile strength of 35,600 pounds. Another analysis from pig, taken in same way, showed as follows from a different chemist:

	Per Cent
Silicon	0.67
Sulphur	0.048
Manganese	0.44
Combined carbon	1.55
Graphitic carbon	1.20

Analysis of iron from hand fired furnaces in the same plant showed as follows:

	Per Cent
Silicon	0.59
Sulphur	0.092
Phosphorous	0.156
Manganese	0.26
Combined carbon	2.97
Total carbon	2.98

As a result of this test, it was conclusively shown that all of the air should be admitted through the burner and arrangements were then made to set up a burner of sufficient capacity for this purpose. At the time of sending this paper to press, reports on additional heats have not become available. It is hoped that further data will be available later.

Another Installation

A 30-inch burner already described has been installed on a furnace, built for a capacity of 10 to 15 tons in a prominent foundry in Erie, Pa. Acting on the idea of having

the initial combustion occur on the front end of the charge, the combustion chamber was made only about 2 feet in length from the noze of burner to the front bridge wall. For reasons noted, this proved to be unsatisfactory and it was considered desirable to lengthen the combustion chamber about 7 feet, thus completing combustion by the time the gases reach the bridge wall so that the extremely hot gases come in contact with the charge.

This lengthening of the furnace, together with other minor changes and adjustments, as well as insufficient mill capacity to supply coal for full time operation, and the fact that the conveying system from the mill to furnace hopper has not been installed, caused delay in placing the furnace in regular operation. It is contemplated to put this unit in daily service as soon as circumstances permit. Unfortunately sufficient heats had not been made, at the time of completing this paper, to give an idea of the melting ratio. The burner has demonstrated great flexibility in operation and can be regulated at will to secure any character of flame desired. The operating staff is well satisfied that the conditions since altering the furnace are such as to give satisfactory results. It is hoped that further data will be available from additional runs to be made with this equipment later.

Malleable Iron Annealing

In malleable iron annealing, the burner described in this paper performs functions equally as satisfactorily as in the air melting furnace. For greatest economy in the use of pulverized coal, the ovens should be of comparatively large size. It then becomes a problem of uniform heat distribution and control so as not to burn the pots. With some types of pulverized coal burners it is found that the heat is thrown in too great degree toward the front end of the ovens. At times the poor heat distribution with high velocity burners results in burning top pots near the burner, while the bottom ones on the same stools may not be annealed. Where a cutting flame cuts down the brick of the firebox, the destruction of pots near the burner may be aggravated from slag deposition and fluxing. At other times, if the coal

FIG. 9—ARRANGEMENT OF TOP BLAST

happens to be a little damp or not ground as fine as usual, some of it may be deposited on the floor and blanket the bottom pots near the burner.

For reasons mentioned, the complete mixture delivered by the burner under consideration, avoiding a cutting flame, largely overcomes the slag difficulties and at the same time prevents an undue part of the hot gasses being driven to the front of the oven. The low feeding velocity gives a certain time element for the gases to expand and normally fill all parts of the oven, especially near the burner. These burners should with proper damper regulation of the oven produce more uniformly annealed castings than heretofore has been the practice. The first of these units on a pot oven is now being installed at Buffalo, N. Y., and it is hoped to have additional data later.

While no commercial installation has yet been made on the muffle type of annealing oven, a number of test runs were made on such an oven handling railway castings. In a plant having 26 ovens of a capacity about 25 tons each, the practice with hand firing was to secure one pound of castings annealed per pound of coal. An improved form of oven was constructed and on a specially conducted test showed a ratio of 2.2 to 1. A 6-inch powdered coal burner on the same oven showed a ratio of 5.2 to 1 and the test record of flue temperature (presently to be mentioned) indicated that the length of this oven could be increased 6 feet without using any more coal, in which case the ratio would be 7.25 to 1. The difference between 1 pound of castings and 7.25 pounds per pound of coal is shown graphically in Fig. 8. On this basis 14 ovens will do the work of 12 and there is a capital saving of $24,000 besides space released for several molding floors, etc.

Temperature readings in the flue, bottom of muffle, top of muffle and in the flame way at end of oven opposite burner, were taken hourly by a thermocouple which had been calibrated. The readings are shown on the chart, Fig. 6, and it will be observed they are not entirely consistent, due in part to condition of the pyrometer and also to changes made in rate of feeding, setting of stack damper, admission of air

at burner, etc. Curves have been drawn to indicate the average of the readings, the ultimate temperature desired not being as high as with pot ovens. By a more rapid rate of firing the temperature could have readily been brought up faster from the twentieth to thirty-fifth hours and the total time of firing might have been shortened two to three hours. The total time of firing, however, was 49.5 hours as compared to the usual hand firing period of 90 to 110 hours on the same ovens. The special hand-fired test showing ratio of 2.2 to 1 was made in 72 hours firing time. The total coal consumption on this run was 9650 pounds and 25 tons of castings were annealed, making the ratio 5.18 to 1. The castings were of excellent quality.

Conclusion

The author feels gratified in being able to record the progress so far made with the air melting furnace. In so far as he has been informed, the installation at the plant at Erie is the first commercial unit to be put in service on an air melting furnace. The 30-inch quadruplex burner there used, with its nozzle delivery of a stream 6 by 60 inches is believed to be the largest single pulverized fuel burner ever built. This installation therefore should constitute an interesting landmark in the development of improved firing methods for the malleable iron foundry.

Powdered Coal as a Fuel in the Foundry

By A. J. GRINDLE, Chicago

The use of powdered coal for fuel has interested foundrymen, manufacturers and engineers for over 100 years, but until the last few years its practicability has been doubted by most engineers owing to the great number of failures which have been made in its preparation and burning.

The possibility of using powdered coal for fuel dates back as far as 1818, when an engineer named Niepce made an effort to burn coal in a coarsely pulverized form over a grate fire. More extensive experiments were carried on later by Henchel, 1831; J. J. Whelphy and J. J. Storer in 1866 to 1871; J. Buhrer, 1867; T. F. Leigh, 1868; T. R. Crampton, 1868 to 1871. Since that time hundreds of patents have been issued covering apparatus and furnaces for using powdered coal as a fuel. The largest portion of these patents cover equipment that modern experience proves could not have given satisfaction even though the coal could have been pulverized fine enough, and at a low cost.

Pulverizing the coal was the greatest difficulty encountered by engineers until the cement manufacturers successfully pulverized and burned this fuel in rotary cement kilns in the year 1895; this application is credited to Messrs. Hurry and Seaman and the Atlas Portland Cement Co. The first satisfactory use in metallurgical furnaces was established in 1911, and in steam boilers in 1916.

Its Use in the Foundry

In malleable and steel foundries using 10 tons of coal per day, or its equivalent in oil, gas or coke, the use of powdered coal for fuel is practical in the opinion of the

author. There are several open-hearth furnaces now using this fuel; steel is being melted with 450 to 600 pounds of coal per ton of charge. There are about 15 malleable foundries using powdered coal for annealing, the fuel ratio on these ovens being from 500 to 700 pounds of coal per ton of castings; much time is being saved in bringing the ovens up to annealing temperature. Malleable iron has been melted with 31.2 per cent coal to iron, a 12-ton heat melted in three hours and 40 minutes with a ton more scrap than usual in place of pig iron.

Steam boilers are being fired with powdered coal and 8½ to 11 pounds of water per pound of coal is being evaporated. If a foundry is equipped with a powdered coal plant it is practical to fire the core ovens with this fuel.

In addition to the fuel saving and savings effected in decreased oxidation of the metal, I believe a saving of 25 per cent to 75 per cent in labor can be made. A more uniform temperature can be maintained and therefore a more uniform product. Core ovens and steam boilers can be equipped with a thermostatic control and the heat controlled as easily as with gas.

Heretofore the small foundry could not use powdered coal for annealing owing to the high cost of an installation compared with the possible savings, but now it is practical for even the small foundry, since it can be used in all departments where fuel is consumed.

Feeding and Burning Powdered Coal

No matter how well coal is dried and pulverized, proper combustion cannot be secured without a uniform feed of coal, thorough carburization with air, and means of easily and accurately controlling the coal and air supply. Equipment has been perfected which overcomes all of these difficulties.

Powdered coal has a tendency to pack in the storage hopper, especially when it stands a few days before burning, and if the opening in the hopper bottom is too small the coal will arch over the feed screw and stop the fuel supply. This trouble has been corrected by a specially designed feed

screw enclosed in a cast-iron hopper bottom with a large top opening. This feed worm will feed throughout its full length. The coal gradually loosens up toward the discharge end in place of packing. At the discharge end there is a revolving disc which breaks up any packing of coal which might take place along the feed screw. Packing causes an unsteady feed of coal and a pulsating flame, but this system eliminates this fault and produces a uniform feed, resulting in a steady continuous flame.

The coal dust is delivered into a mixing chamber connected to a low-pressure air line where it is mixed with the air for combustion and carried to the carburetor which may be from 3 to 100 feet from the coal control.

The air is supplied by a low pressure blower, at about 3-ounce pressure and enters the furnace at 1/4 to 3-ounce pressure, depending on the length of flame desired. By having a speed-change box connected to the coal screw shaft it is possible to accurately control this speed which in turn controls the amount of coal being fed to the air line.

The air supply is controlled by a specially designed air gate which is marked to correspond with the number of square inches the gate is open. In addition to this marking, there are adjustable markers corresponding to the coal screw speeds; these markers can be adjusted so that the coal and air are synchronized when each are set on the same number. This control of air and coal is very simple and can be handled by an inexperienced person after one demonstration. By this method, the markers can be set in accordance with the carbon-dioxide analysis of the stack or by an expert combustion man after which a laborer may operate the apparatus and know that he has the air and coal proportioned correctly.

The Problem of Carburization

The coal and air are partly carburized while traveling through the coal carrying line, but to assure complete carburization the coal empties into a carburetor in which is placed a stationary fan-like mixer, the outlet end of this carburetor is fan shaped which causes the flame to spread

across the furnace and to ignite more readily. A dust cloud is ejected from the carburetor through a nozzle of the same shape as the outlet end of the carburetor. Every particle of coal dust is surrounded by the right amount of air for combustion and burns in a steady, continuous flame.

The adaptation of powdered coal burners to different kinds of furnaces varies according to the temperature and class of work to be done. Some flames are directed horizontally and others down or upward. A nozzle which allows the operator to control the flame without interfering with the coal and air supply has been perfected. This nozzle has two plates which can be raised or lowered directing the flame up or downward and by bringing the two together, the flame can be lengthened. The success of the furnace sometimes depends upon the ability of the operator to control the fire in this way.

When using powdered coal the efficiency of the furnace does not depend upon the draft from the stack; all that is required from the stack is that it carry off the burned gases. This means a great deal when present stacks are insufficient to take care of grate and stoker fires and when new stacks are being built.

There have been many kinds of pulverizers developed, starting with burr stones and bolting cloth. Later rotary barrels filled with balls between which the coal was ground were used. In addition to this equipment it was necessary to provide elevating and conveying machinery to handle the pulverized coal. Grinding rooms were frequently dust-laden infernos. The inefficient, crude machines of the early days were a constant expense to mill owners and dust polluted air was a constant injury to health of employes. But now we have the roller mill with air separation which eliminates all dust, pulverizes uniformly at a low cost for power and repairs. A powdered coal plant properly installed is perfectly dustless from the time the coal is fed to the dryer until it is burned.

A cubic inch of coal exposes six square inches of surface for the absorption and liberation of heat while coal pulverized to such a fineness that 85 to 95 per cent will pass

through a 200-mesh test sieve divides this cubic inch into millions of minute particles, which if suspended in the atmosphere and surrounded with the correct amount of air to complete combustion exposes over 20 square feet of surface.

As combustion is obtained by the combination of the carbon and hydrogen in the coal with the oxygen in the air, it is readily seen why powdered coal can be burned with such a saving; every minute particle is surrounded with exactly the right amount of air for its complete combustion (it requires about 150 cubic feet of air to burn a pound of coal, depending on the quality of coal used); this leaves no waste as smoke or carbon in the ash, and when the heat is not required, the flame can be immediately extinguished, thereby avoiding having coal burning in a banked bed, as is the case in any other method of coal burning.

Economy of Powdered Coal

The cost of fuel of any kind must be based on the B. T. U. cost. If oil costs 5 cents per gallon and contains 19,000 B. T. U. per pound, we would get 25,384 B. T. U. for one cent. If coal costs $5.00 per ton and contains 13,000 B. T. U. per pound, we would get 52,000 B. T. U. or more than twice as many heat units from coal for a cent. These comparisons can be made with any fuel and coal, and invariably the coal will be bound to be the cheaper.

Fuel oil and natural gas fluctuate in price and tend to become more expensive as demand increases; this is not true to any great extent with coal.

When burning coal on a grate much combustible material drops through the grates mingled with the ash and goes up the stack in smoke. Also when the fire is no longer required there is no benefit derived from the coal left on the grate. It is not possible to thoroughly mix the air with coal on a grate, even when burned on the most advanced chain grates.

Careful experiments show that in the average fuel-bed fire it is necessary to supply at least 40 per cent more oxygen

or air than is actually consumed to secure perfect combustion and the elimination of smoke. When fresh fuel is added to the fire the excess oxygen is used for the moment to burn the hydrocarbons; at other times it is going through unused causing the metal to be oxidized or the temperature reduced. If the air supply is kept lower, there is not enough oxygen supplied to burn the carbon or hydrogen when fresh fuel is supplied; more heat, however, is produced but at a considerably increased cost for fuel and the formation of volumes of black smoke with its many well known objections.

These faults with the old system of heat generation are overcome when powdered coal is used, as the air and coal can be kept at exactly the right proportion at all times and a steady heat produced; this, in addition to the ability to direct the heat in the proper direction, accounts for the savings which are being made by using powdered coal for fuel. Savings are being made in fuel and labor cost of from 10 to 40 per cent over hand and stoker fired furnaces and boilers and as high as 62 per cent over oil burning furnaces. In addition to these savings there is a saving of 1 to 5 per cent in oxidation loss of metals in metallurgical furnaces, and production is being increased 15 to 25 per cent. I believe a powdered coal installation will save its cost in one to three years.

Kind of Coal to Use

Coals best suited for burning in a powdered form are those rich in volatile matter, such as bituminous and semibituminous, either slack or run-of-mine. The slack has an advantage over the run-of-mine as it is not necessary to crush the former before drying.

The following analysis represents a coal which has been found to give excellent results on melting furnaces:

	Per Cent
Fixed Carbon	60.12
Volatile Matter	35.80
Ash	3.08
Moisture	1.00
Sulphur	0.38
B. T. U.	14,650

Good results have been obtained in annealing ovens and steam boilers from coal of the following analysis:

	Per Cent
Fixed Carbon	53.26
Volatile Matter	29.00
Ash	16.34
Moisture	1.40
Sulphur	1.80
B. T. U.	12,600

Qualities of anthracite lignite and peat, as well as the inferior grades such as anthracite culm, dust and slush, and bituminous and lignite slack screenings and dust are all suitable for burning in pulverized form, for certain kinds of work, when dried and properly mixed with a higher volatile fuel.

For the proper igniting and burning of powdered coal the volatile content should be 20 per cent or more.

In the ordinary method of burning coal the bed of solid incandescent fuel is more or less encumbered with ash and clinker, which causes a varying and irregularly distributed resistance to the passage of air and causes some of the unburned coal to sift to the ashpit or to be fused in with the clinker.

With powdered coal, burned in suspension these difficulties disappear excepting getting rid of the incombustible material. When a coal containing 10 per cent ash is used there is 200 pounds of refuse to be disposed of for each ton of coal burned; about 30 pounds of this goes up the stack in the form of a light powder, hardly visible at the top. The balance of the ash settles in the furnace or flues and in high temperature furnaces melts, forming a slag.

By the proper flue arrangement it is possible to take care of this fine ash; it takes about one-quarter of the labor which is necessary to take the ash containing much unburned carbon from under a grate or stoker. The disposal of slag from the high temperature furnace has caused much more trouble. When most ash reaches a temperature of 2300 degrees Fahr. it melts forming a slag, and is liquid at 2500 degrees. Most attempts to dispose of this slag have failed, because it chills and becomes like a tough wax and it is

almost impossible to get rid of, unless it is removed from the combustion chamber in a molten state without allowing cold air to come into contact with it. Some concerns let the slag accumulate for several days, cool the furnace off, which makes the slag brittle, and remove it with sledges and bars; this method not only interferes with production in the plant, but is very laborious and is injurious to the brickwork.

This problem has now been solved. In the furnace construction the ash is melted in the combustion chamber and dropped through the bottom in small drops, as slag, into water where it is easily removed, either by raking it out with a hoe, or by conveyor or elevator when much coal high in ash is being burned. The bulk of ash in this form is less than 10 per cent of that which would be taken from under a grate or stoker fire.

Preparing Powdered Coal for Burning

Although not necessary, it is very convenient to have a large coal storage near the pulverizing plant. Some plants have been installed where a storage of 1000 tons was placed under cover. In all powdered coal installations a hopper is supplied with capacities ranging from a few hundred pounds to carloads. Under this hopper there is an apron, an oscillating plate, or a belt feeder which feeds the coal from the storage room hopper onto a belt conveyor. In the case of a belt feeder the belt serves as the conveyor.

This conveyor carries the coal over a magnetic pulley which extracts the tramp iron, such as pick points, railroad spikes or scraps of pig iron which are left in cars when unloaded. This is done to protect crushers and feeders in the preparation system.

From the belt-conveyor the coal is delivered into a single-roll coal crusher, which breaks it up into 1½-inch or smaller pieces. A few years ago screenings from coal containing less than 80 per cent lump were not salable but with the use of powdered coal and stokers this condition no longer exists. Many of the mines are installing crushers to meet the steady increase in demand for small sized coal. In some localities it is possible to purchase crushed coal but in others

it is necessary to install a crusher to do this work at the plant; from the crusher, the coal is elevated to a wet coal storage hopper ranging from one to 50 tons capacity.

It is good practice to place an automatic scale over the wet coal hopper so that an accurate record of fuel consumption can be kept. The coal is automatically fed from the wet coal hopper to a dryer. To secure the best results from powdered coal it must be dried to less than 1 per cent moisture.

This is an item of cost that cannot be eliminated regardless of whether the coal is burned on grates or in suspension. When undried coal is fed into the furnace, the moisture (both free and combined) is evaporated in the furnace itself, which means an added quantity of coal to maintain the temperature which is reduced several degrees for each 1 per cent of moisture in the fuel. As this cannot be overcome by feeding additional fuel with the same percentage of moisture the loss of heat is about 2 per cent for each per cent of moisture.

By drying the coal before pulverizing, the cost of the operation will be almost saved in the decreased power necessary for pulverizing and in the improved combustion resulting from the greater degree of fineness of the artificially dried as compared with moist coal. Moreover, the dry coal will readily flow and give less trouble through tendency to pack, clog and adhere during the process of grinding, conveying, storage and burning.

The Pulverizer

From the dryer the coal is delivered to an elevator which discharges into a 1-ton to 5-ton storage hopper; from this hopper it is automatically fed to a pulverizer. Powdered coal must be pulverized to a fineness so 85 to 95 per cent will pass through a 200-mesh test sieve; this fineness depends upon the type of furnace to be fired. When coal is ground to 85 per cent passing through a 200-mesh test sieve, about 95 per cent of this coal would pass through 100-mesh, and 50 to 60 per cent through a 300-mesh. The most efficient and dustless system of pulverizing is by the roller mill with air separation. This system delivers the coal to a storage bin without the use of elevating and conveying machinery.

During the process of pulverization the coal is delivered to a conveyor or a storage hopper of 5 to 30 tons capacity from which it is conveyed to hoppers of ½ to 10 tons capacity located at or near the furnace. There are two satisfactory systems for conveying the powdered coal, namely, the screw conveyor for short distances and the high pressure air transport system which conveys the coal as a solid without mixing with great quantities of air.

Pulverized coal should always be handled as a solid and not as a dust cloud when it is to be conveyed to hoppers or long distances. To convey it by large portions of air insures a mixture of coal and air which is somewhat dangerous, and as it is necessary to separate the coal again into a solid, this system is apt to develop leaks and cause very dirty surroundings. The requirement of velocity in the air current sufficient to float the coal along causes an expenditure of power greatly in excess of that required for handling as just described.

Powdered coal should not be stored more than two or three days before burning as it absorbs moisture very easily from the air. This fuel has been stored for three months and burned, but much trouble was caused in getting it out of the hopper as it had absorbed moisture, smoldered and formed a coke-like substance which interefered with the feeding. With the proper feeding equipment, a good fire can be secured when coal has stood a month, but this is not good practice, because of the efficiency lost in moisture and sometimes in the spontaneous combustion of the coal. It should not be understood that it is dangerous to store powdered coal as this is not the case; the only time that powdered coal is dangerous is when it is in huge volumes of air and moving slowly. Storage capacity is supplied for 24 hours run in most installations.

The Cost of Powdered Coal

The cost of preparing powdered coal for burning runs from $0.46 to $1.00 per ton depending on the amount pulverized. The cost of an installation runs from $18,000 to $150,000 according to the capacity and number of the furnaces to be fired.

Discussion

Mr. W. H. Fitch.—The remark was made about three or four weeks ago that one could not melt steel in an open-hearth furnace and iron in an air furnace successfully with pulverized coal, and as the gentleman in question is an engineer engaged in building plants and advising accordingly, I think those who know differently ought to combat it. We are melting iron successfully today in the plants of one of our clients and have melted steel in open-hearth furnaces over a period of four years. I think that means that it is practical, to say the least.

Some months ago one of the malleable companies wanted a modern pulverizing plant to operate a battery of annealing ovens. Eventually the question of melting iron with pulverized coal came up and we applied it to one of the air furnaces. That furnace is in service now producing 30 per cent more now than when it was hand fired. The quality of the iron is first class, and all the labor used in hand firing has been eliminated.

We took the grate bars out of the furnace and made it similar to an open-hearth furnace above the floor level, obtaining 18 tons per heat where before we got about 13 maximum. The complete cycle is made in about two hours less time than with hand firing, producing about 36 tons in the two heats. The average fuel ratio is 4½ to 1. We have got as high as 4.87 pounds of iron to a pound of coal.

The condition of the refractories is first class; in fact, better than they were when the coal was hand fired. The saving on the brick work compared with hand firing is not known definitely but is estimated to represent several hundred dollars per annum.

There is no particular difference between this furnace and hand fired furnaces, except that the grate bars are removed, increasing the hearth area. There are two burners on the furnace in which the coal is thoroughly mixed, the combustion air is added and then projected into the furnace. One can rest his hand on the burner as it is cool at all times. The furnace is about 250 feet from the line which serves the large muffle

furnaces. Coal is pumped to the pulverized coal bin at the melting furnace through a $3\frac{1}{2}$-inch wrought iron pipe in much the same manner as water is handled, so far as velocity is concerned.

Mr. Fitch.—I have just been requested to say a few words about mixing coal dust with fuel oil. During the war the government called upon us to do some work in this connection as applied to steaming. For several months a steamer was operated on Long Island sound in making these experiments. Different mixtures of oil and coal dust were made and applied successfully. As high as 80 per cent of coal dust in a gallon of oil was reached and there were no detrimental effects.

For any one of those who contemplate the use of different kinds of fuels I think that it is merely a question of how much heat can be obtained for a dollar.

Mr. Enrique Touceda.—I think Mr. Arrowood is in error in thinking he can reduce the annealing time to 18 hours. A certain length of time is required to bring castings up to temperature, while they cannot be held at temperature for much less than 48 hours in commercial practice. Also, the castings should not be cooled from temperature at a rate less than 10 degrees per hour. There seems to be a tendency in the industry to endeavor to shorten the anneal, and it is doing a great deal of harm. I believe that we should fight any such propaganda as that, because I think the attempt is absolutely in the wrong direction.

Now in connection with the quick heating of the oven to temperature, there are practical propositions to consider which if taken into account will cause trouble. For instance, if an oven is heated to temperature in 15 hours, the rings will expand more quickly than the contents within it, because the heat cannot be absorbed by the contents as fast as by the metal in the ring; the result is that as the rings expand the packing will bleed from the upper ones to those lower down, and in extreme cases the castings in the topmost ring will be found to be unprotected by packing.

A Member.—There are representatives here from the Malleable Casting Co. I should like to hear what they have to say

as I understand the company now is melting with powdered coal.

MR. A. J. GRINDLE.—At a recent installation we had 19 successful heats and no bad ones. Every heat was hot and each took a little shorter time than the preceding one. The first took 7 hours 45 minutes to melt. Last Thursday afternoon we ran the second heat in a small furnace, the maximum capacity of which was 10 tons. The furnace was only 5 feet wide inside and 15½ feet long between bridge walls, so that it is not fair to compare this furnace with a large one which can melt 12 or possibly 25 tons. On the first heat on the last runs we melted a heat in 4 hours 25 minutes, ready to tap. It took an hour and five minutes to take the heat out of the furnace on account of the small number of molders around the furnace. We melted 8.142 tons of metal with approximately 590 pounds of coal per ton. The percentage of pig iron was 43. The melt per hour was 1.48 tons. The carbon was 2.44 per cent, silicon, 0.92; sulphur, 0.094; and manganese, 0.28. We thought when we started the furnace that we were likely to pick up the sulphur; therefore we built the furnace extra high so that we could get good combustion before we heated the metal. We find it runs about 0.01 lower. On the first heat on the next day we melted 9.29 tons in 5 hours 25 minutes. The total time on that heat was 6 hours and 10 minutes until the heat was out. We had 41 per cent pig iron on the start and at one time were down as low as 35 per cent pig, but we found it advisable to change our furnace. The furnace is equipped so that we can fire coal in the top blast, and we decided to take the coal off the top and use only air here. We threw ourselves back about a week on the results that we had been getting, but we found when the top blast was on the pig iron went up. These results were obtained when using air and no coal on the top. The coal we were using analyzed moisture, 2; volatile, 37.43; fixed carbon, 54.98; and ash, 5.9 per cent. The sulphur was 0.768 and the British thermal unit value, 13,605. The sieve test was: Two hundred mesh, 84 per cent; 240 mesh, 80 per cent, and through 300 mesh, 56 per cent.

Melting in An Air Furnace with Fuel Oil

By J. P. Pero, East St. Louis, Ill.

I have been unable to find any literature bearing upon the use of fuel oil in air furnace practice. For some reason unknown to me very few have tried or at least adopted oil as a fuel in air furnace melting. I have tried to get in touch with everybody using oil for this purpose in order to present the subject as thoroughly as possible, but have been able to get data from but two malleable iron foundries. The facts presented in this paper embody not only my personal experience but in its essentials describe the practice of two other malleable iron manufacturers who have been very successful in the use of fuel oil in air furnace practice.

For a number of years I considered the advisability of using oil for melting, but was unable to get any information to assist me in the various details of furnace construction and operation, until about three years ago I learned that the Iowa Malleable Iron Co., Fairfield, Iowa, was working along these lines and partly by collaborating with this concern and partly by the adoption of my own ideas, and by much experiment I succeeded in producing most excellent results in every essential except in economy of fuel cost, which item is really relative and is governed by the comparative cost of coal and oil in any given locality. Unfortunately, the relative cost of the two fuels in my plant was such that the actual fuel cost of coal was the cheaper of the two. With a knowledge of the relative cost of oil and coal in your locality, you can from the data given in this article readily determine which of the two fuels will be most satisfactory. There are several features other than economy of fuel cost that should be given consideration in choosing between the use of coal and oil, and my opinion is that in prac-

tically every essential feature of furnace practice other than the cost of fuel, oil is unquestionably preferable to coal.

Few Disadvantages

The only disadvantages I have found in the use of oil as compared with coal is the increased cost of the fuel itself, which item will vary in different localities according to the distance from the sources of supply of the different fuels; for instance in a locality having a long haul on coal and a short haul on oil, the difference in fuel cost per ton of iron melted might be negligible.

As an example, the Jewell Steel & Malleable Iron Co., in its San Francisco plant, found that oil with a consumption of 65 to 66 gallons per ton of iron melted in a cold furnace was not only very much preferable to coal but absolutely cheaper, due to the fact that coal is abnormally high priced on the Pacific coast on account of an extremely long haul while oil was delivered on a very short haul. In my plant I found the fuel cost per ton of iron melted by oil nearly double the cost with coal.

In addition to the increased cost of fuel, the only disadvantage I have found in the use of oil is excessive oxidation of the carbon, silicon and manganese contents. Just at this time when we are paying a premium on pig iron with a high silicon content, this feature is a disadvantage. On the other hand the absorption of sulphur is so slight in using oil that it is possible to use a high sulphur iron which can always be bought at less than market price for standard grade.

Among the many advantages in the use of oil are positive control of the melting, rapid melting, much lessened cost of furnace repairs, absence of cinders, reduction of the furnace gang to one man and economy in coal handling. There are many minor advantages. I have named only the principal ones.

In controlling the melting of the heat, without effort other than the opening or closing an oil valve, or the admission of more or less air from the blast, the melter can bring about almost any results he desires. I have seen a heat of 14 tons in a melting chamber 21 feet 6 inches long and 6 feet wide solidify after having been

melted, due to an accident in the pipe line, and in five hours after starting the fire again the heat was remelted, hot, and saved by the use of ferrosilicon and ferromanganese. This would have been impossible in a coal-fired furnace. We commonly melted 15 to 17-ton heats, charged in a cold furnace, in 4½ to 5 hours, and a 12 to 15-ton afternoon heat charged in a hot furnace in 3½ to 4 hours. As our coal is unloaded from the car at a point from which the fireman throws it into the furnace, we could show no economy in handling coal. You can readily estimate from conditions in your plant and determine whether you could economize in this respect, as well as in the disposition of cinders and ashes.

I am unable to furnish data on the comparative cost of repairs as it is our custom to repair each furnace every week, or after 12 heats, in order to have each furnace repaired in regular rotation, since we have six furnaces in one of our foundries. But we know positively that the oil-fired furnaces were in much better condition on repair day than were the coal-fired, and they undoubtedly would have run several more heats safely.

One-Man Furnace Gang

We had but one man in the oil furnace gang. He very comfortably took care of the skimming and loading the slag on the car, as well as the tapping. We have but one spout on most of our furnaces; but on a few of them there are two spouts. Our furnacemen were so pleased with the oil furnaces that there was a bitter rivalry among them to work on them in preference to the coal-fired. Under present labor conditions, this feature is one whose value in dollars and cents cannot be estimated.

I regret that owing to lack of time, due to additional duties, I have taken on for the past few months, I have been unable to embody in this paper a sketch of the principal dimensions of my furnaces, but will try to describe them so that they may be readily understood. Our furnaces are 21 feet 6 inches long between front and back bridge walls, and 6 feet wide. Our bungs have a 9-inch spring to the arch. We made

no change in the back bridge wall. In getting the lines of the furnace we started at the skimming doors for a level. After having torn down the front bridge wall to a point 2 inches above the level of the skimming door, we filled up the old fire box with brick bats placed on top of the grates. Our combustion chamber occupied the space over the former fire box and extended to a point 10 feet from the front bridge wall, the opening at the firing end extending to the end plate of the furnace, and at this end the bottom of the combustion chamber was about 24 inches above the level of the new front bridge wall, or about 26 inches above the level of the skimming door. The bottom of the combustion chamber was made of silica sand and sloped in a straight line from the firing end to the front bridge wall. The opening at the firing end was 16 inches wide and 20 inches high, into which was inserted the blast pipe which at the opening was 13 inches square, and upon top of which the burner was placed. A 14-inch diameter blast pipe furnished the air. It was controlled by a slide valve. In addition we used our regular top blast, through the regulation of which we secured air necessary for complete combustion. The side walls of the combustion chamber were 30 inches above the front bridge wall and ran in a straight line to a point 20 inches above the bottom of the chamber at the firing end. In other words, the combustion chamber was the width of the furnace, 6 feet at the bridge wall, and 30 inches high on the sides, with an additional height of 9 inches resulting from the arch spring in the center of the bungs; it gradually narrowed to a width of 16 inches, and a height of 20 inches on the side walls, with an additional height of the spring of the arch in the center of the bungs. The side walls were 12 inches above the back bridge wall, gradually sloping in a straight line between these points. We made no change in the lines of the furnace between back bridge wall and stack. The oil was pumped through a registering meter to the burner by a direct connected centrifugal pump, at a pressure of 12 to 14 pounds after being heated to 100 or 110 degrees Fahr. It was atomized by compressed air, or superheated steam at a pressure of 25 to 35 pounds.

We learned that we could regulate the blast, both direct and top, more effectively from the appearance of the gas than by any fixed rule, and also learned that much less air was used than in burning coal.

Accompanying this paper are given data on the construction and operation of furnaces in three different plants. The table follows:

	Mo. Mall.	Iowa Mall.	Jewell Mall.
1.—Length of furnace between front and back bridge wall, feet and inches	21-6	22-6	21-6
2.—Width of furnace inside, feet and inches	6-0	5-10	5-9
3.—Capacity in tons	12 to 17	12 to 15	11 to 15
4.—Length of combustion chamber from burner to bath, feet and inches	10-0	8-1	11-0
5.—Width of combustion chamber at burner, inches	16	14	13
6.—Width of combustion chamber at connection with bath, feet and inches	6-0	4-7	5-9
7.—Depth of combustion chamber on skew-back line at burner, inches	20	14	14
8.—Depth of combustion chamber on skew-back line at front bridge, inches	30	33½	20
9.—Gravity of oil	26-30	26-30	Not known
10.—Temperature of oil, degrees Fahr.	100 to 110	150	180
11.—Atomizing pressure, pounds	25 to 35	Not given	15
12.—Diameter main blast pipe, inches	14	14	Not given
13.—Diameter top blast pipe, inches	9	10	7
14.—Number of outlets top blast pipe	6	5	2-2 in. and 4-3 in.
15.—Diameter of outlets top blast pipe, inches	3	4	See above
16.—Volume of blast in main pipe, cubic feet per minute	Unknown	3500	3200
17.—Size of melt, tons	12 to 17	12 av.	7 to 11
18.—Time of melt cold furnace, hours	4½ to 5	4	Av. 2 tons per hour
19.—Time of melt hot furnace, hours	3½ to 4	3½	1 heat per day
20.—Oil consumption per ton of iron melted, gallons	70 to 75	60 to 66	65 to 66
		Per Cent	
21.—Oxidation of carbon, cold furnace	0.50 to 0.60	25 to 30	0.70

	Mo. Mall.	Iowa Mall.	Jewell Mall.
22.—Oxidation of carbon, hot furnace	0.40 to 0.50	25 to 30	......
23.—Oxidation of silicon, cold furnace	0.40 to 0.50	25 to 30	0.50 to 0.60
24.—Oxidation of silicon, hot furnace	0.30 to 0.40	25 to 30	......
25.—Oxidation of manganese, cold furnace	0.35 to 0.40	35 to 40	0.36
26.—Oxidation of manganese, hot furnace	0.30 to 0.35	35 to 40	......
27.—Gain in sulphur content	Not appreciable	None	None
28.—Cost of repairs as compared with the same furnace working coal fired	Much less	Considerably less	Less

I take this opportunity to express my thanks to the Iowa Malleable Iron Co. for information and co-operation given me during my early experiments and for data given. I also thank the Jewell Steel & Malleable Co. for data given. I sincerely hope and believe that in the near future there will be evolved a plan by which fuel oil will be economically used in air furnace practice.

The Refining of Cupola Malleable Iron in the Electric Furnace

By A. W. Merrick, Schenectady, N. Y.

The American or blackheart malleable cast iron produced in this country is usually melted in air (or reverberatory), open-hearth or cupola furnaces. Either of these types of furnaces offer certain inherent advantages and disadvantages, but as it is with the last named that we are to deal in this paper, the discussion will be limited to this one method of melting.

Its advantages are briefly as follows: Low initial investment; low cost of operation, upkeep and repairs; intermittant or continuous operation which gives a great flexibility of capacity; high melting ratio of iron to fuel; and ability to melt high percentages of cast iron and steel scrap without the consequent lowering of the carbon content which would necessarily follow in either of the other two types of furnaces. From the foregoing it will be seen that the cupola will produce molten cast-iron at the spout cheaper than any other type of furnace, and this fact is universally conceded by all authorities.

There are, however, certain disadvantages in cupola melting as applied to cast iron in general and malleable cast iron in particular. First, the sulphur absorbed from fuel is higher with this process than either of the others. Secondly, it is not possible to produce an iron of a low carbon content, which with malleable iron limits one to the production of castings of very light section. This is due to the fact that the melting stock, being in intimate contact with the incandescent carbon of the fuel, absorbs carbon so readily, that with the constant silicon aimed for in malleable iron, a practically saturated condition is reached so that with other conditions equal, the carbon is never very far either above or below a fixed point. This holds good even where the percentage of steel in the charge is varied considerably. Thirdly, cupola iron, especially on long heats, is liable to quite a variation in temperature and

composition. The latter evil is especially aggravating in malleable work where the importance of keeping the two elements sulphur and manganese, in a proper relationship is well recognized.

Used as a Mixer

In order to overcome these last two disadvantages we might utilize some sort of a mixer that would act as a reservoir and by holding a given quantity of metal allow it to become

FIG. 1—RESULTS OBTAINED WITH TEST WEDGES OF LOW MANGANESE IRON

constant in temperature and composition. The difficulty with this plan, is of course, that the temperature of the molten metal would be constantly lowering unless some external source of heat were applied, so that the question narrows itself down to just what this source of heat would be. The electric furnace, at once suggests itself as ideal, for in addition to supplying the heat needed, it will also allow the removal of the greater part of the sulphur by use of a proper slag. Not only this, but it will, in addition, allow an iron of any carbon con-

tent to be made by the means of additions of either cold or liquid steel, so that compositions of any range of carbon and silicon can be made and any castings of sections practicable in malleable iron may be poured.

The advantages of such a duplex process are readily apparent to anyone familiar with the production of cupola malleable iron. Cupola iron is especially suitable for castings of light section, such as pipe fittings, etc. In the latter case where an iron high in carbon is desirable, because of the greater ease of threading the fittings this process should recommend itself immediately. In addition to the advantages previously enumerated it would permit the annealing of the white iron at a considerably lower temperature than is practicable with a high sulphur iron, such as is ordinarily produced in the cupola.

Results of Experiment

In order to determine how far it is possible to reduce the sulphur in cupola iron in a reasonable length of time by this process, some sprues and scrap were obtained from a manufacturer of cupola malleable iron and melted in a small Heroult electric furnace. The material had the following composition: Silicon, 0.65 per cent; manganese, 0.53 per cent; phosphorus, 0.143 per cent; sulphur, 0.20 per cent, and carbon, 3.06 per cent. This analysis was supplied by the firm which furnished the scrap and was given as the average. No attempt was made to check it due to the difficulty of securing an average sample of material of this nature.

The scrap was melted bare in the furnace and then a basic slag of lime thinned with spar was put on. Finely ground petroleum coke was sprinkled over the slag to reduce all oxides throwing the metals back into the bath, the slag turning a creamy white color, indicating the completeness of these reactions. Calcium carbide is formed in the slag as is evidenced by the pronounced odor of acetylene when such a slag is moistened in water. A slag of this character will readily absorb sulphur from the bath and while the reactions require some time for completion, the practical elimination of the sulphur is very rapid.

Accordingly, 15 minutes after the slag was made a sample was taken for analysis, with the following results: Silicon, 0.57 per cent; manganese, 0.54 per cent; sulphur, 0.057 per cent; and carbon, 3.36 per cent.

Note the reduction of sulphur which is very striking when it is considered that the sample was taken just 15 minutes after the formation of the slag. There is something further of note, namely the retention of the manganese. This element is readily oxidized in the cupola and it is customary to run the mixtures very high in manganese to take care of what is burnt out in melting and still leave enough for the high sulphur that is obtained. With the electric furnace, no speigeleisen, ferromanganese, or high manganese pig is necessary, and in fact, as will be later shown, the mixtures, to get best results, would have to be kept low in this element. As was mentioned before, the analysis before melting was supposed to represent the average

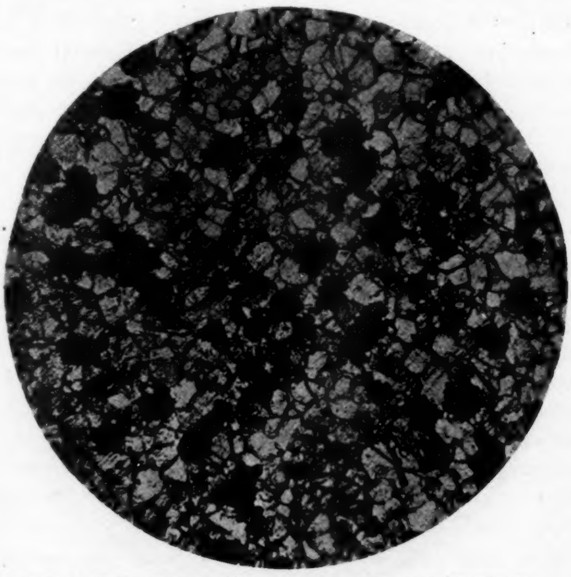

FIG. 2—STRUCTURE OF CENTER OF TEST BAR AT 70 DIAMETERS

so that the slight difference of silicon obtained need not be considered. The carbon, however, seems to have increased, but there is a possibility of doubt here, as 3.06 per cent seems rather low for cupola iron in the first place. Then again, when carrying a refining slag on low carbon steel, which is greedy for carbon, the increase due to additions of coke to the slag are so small as to be negligible.

At the same time the sample was poured for analysis, a set of test bars was poured and after cooling the bars were broken and fractures examined. The bar ⅝-inch in diameter was clear white and the 1¼-inch bar nicely mottled so that the composition seemed all right for the class of material under consideration. A set of test bars and wedges for annealing was then poured.

Steel and Ferrosilicon Added

In order to obtain iron more suitable for work of a heavier section, some steel and ferrosilicon in calculated amounts were added to the bath. The calculation was based on the 3.08 per cent of carbon as supposed to have been in the original material but as it was actually higher in carbon the result was higher than desired. However, it was near enough for the purpose, to illustrate the possibility of producing an iron of a lower carbon than is ordinarily obtained in the cupola. The actual analysis is given as follows: Silicon, 0.75 per cent; manganese, 0.53 per cent; sulphur, 0.036 per cent; and carbon, 2.90 per cent.

It is interesting to note in passing that the analysis obtained was exactly that expected, taking into consideration the actual first analysis, and the analysis and amounts of the additions. Anyone who has had experience in adding ferrosilicon to an air furnace where a strongly oxidizing condition prevails, to bring up the silicon, can appreciate this. The sulphur is still lower in this sample, which can be attributed to the further refining of the slag, for even had the steel contained no sulphur the resultant would have only been 0.045 per cent, had the slag not absorbed more from the bath.

Test bars of this composition were poured and both sets of bars were subsequently sent to the firm that supplied the

scrap for annealing. They were packed in the second pot from the bottom and placed in about the middle of the oven.

The examination of the bars after annealing showed that the metal was inclined to be rather "short" and that it lacked toughness. This might easily be expected when the high manganese, low sulphur composition is taken into consideration. The fractures viewed with the eye looked like typical blackheart iron with the exception that the rim of ferrite is heavier

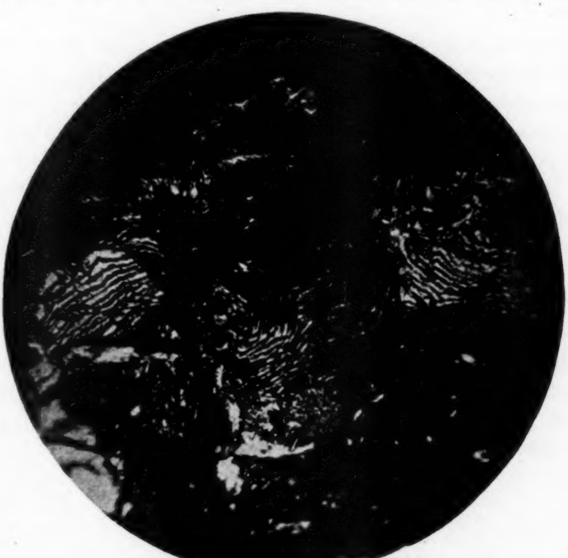

FIG. 3—STRUCTURE OF RIM OF TEST BAR AT 320 DIAMETERS

than usual. Under the microscope, however, we find that the structure consists of a rim of ferrite and the interior a matrix of ferrite and pearlite embedded with temper carbon, instead of a pure ferrite matrix, characteristic of good blackheart iron.

Sulphur Eliminated

As it was impossible to obtain any low manganese, high sulphur cupola iron without making it especially for our

purpose, a mixture of gray scrap, washed metal and steel was melted to give a composition approximately that obtained by refining a cupola iron high in sulphur but low in manganese. Bars were cast from this heat as previously and annealed. The composition was similar to the first lot prepared except that the manganese was 0.14 per cent and the sulphur 0.009 per cent. In this case where the sulphur was low to start with, it had practically been eliminated by the action of the slag in the furnace.

These bars after annealing were quite a lot better than those first prepared, containing manganese over 0.50 per cent. The test-wedges could be curled up more, as is shown in Fig. 1. The tensile strength of this composition is from 38,000 to 40,000 pounds, but the elongation in 2 inches is only 3.5 per cent. The molding was bad and these were very defective looking bars. The bars when polished and etched, showed an improved structure over the first set but still show some pearlite in the rim, although the center of the bar shows the typical blackheart structure. This is shown in the photomicrographs Figs. 2 and 3.

The conclusion to be drawn from this result is that evidently there is still too great an excess of manganese present for the low sulphur and some further work is planned to verify this.

Conclusions

Among the conclusions which the author arrived at are the following:

1—The cupola is the cheapest method for producing molten cast iron, but the process has several inherent disadvantages that have limited the use of cupola malleable to work of light sections. It produces iron high in sulphur, and variable temperature and composition.

2.—The electric furnace is capable of refining this iron, reducing the sulphur to a negligible amount and superheating the metal to any desired degree without any further altering of composition.

3.—Such a process as described will permit iron of any carbon and silicon desired to be made by the proper additions of steel and ferrosilicon to the bath.

4.—Where this duplex process is used, the amount of scrap used in the cupola can be increased and the fuel decreased as it would not be necessary to have the iron as hot as is the practice when poured direct into the molds.

5.—The mixtures would have to be kept low in manganese, no high manganese pig or spiegeleisen would be used and it is believed that by using low manganese scrap the amount of manganese burned out in the cupola would lower this element to the point desired. This will have to be worked out definitely in the future.

6.—As to costs, no figures can be given as the process is not believed to be in operation as specifically outlined in this paper. However, the power required ought not be more than 150 to 200 kilowatt hours per ton on molten metal from the cupola and with continuous operation, the labor charges should not be excessive. These costs would be offset by the lower cost of melting stock, reduced amount of coke used in melting and the lower temperature of the annealing ovens for the annealing of such low sulphur iron.

Relation Between Machining Qualities of Malleable Castings and Physical Tests

By Edwin K. Smith and William Barr, Milwaukee

During the past year or so, there has been considerable discussion of the machining qualities of malleable castings. At the same time there has been a decided tendency toward raising the physical characteristics, especially the tensile strength and elongation. This naturally has brought up the question: "What effects have the higher physical properties had on machinability?" There are wide differences of opinion in regard to this, and as the subject is of importance to manufacturers, as well as to users of castings, it seemed advisable to collect the available data, in order to present at least a preliminary report at this time. On getting in touch with various foundries, it became evident that there are two general opinions, and that practically every concern has a strong leaning toward one or the other of these opinions.

One set maintains that machinability is practically independent of physical characteristics, and that castings showing high tensile strength and elongation machine quite as well as those with lower physical properties. The other group feels equally strongly that in certain lines of work, where extremely high strength is not necessary, greater ease and speed of machining can be obtained by using a metal with lower physical characteristics. There is no question as to what metal to make when great strength is the prime requisite.

There is little literature on this subject. A paper presented at the American Foundrymen's association convention in Boston in 1917 recommends the manufacture of malleable with high characteristics, but admits that with such

The column in Tables I, II and IV marked "Decarb" gives the depth to which the carbon was burned out in the anneal. From these preliminary experiments, we were not able to find any relation between depth of decarbonized rim, and machinability, but we believe that this suggestion is well worth further investigation.

extra good material, the user may have to increase the strength of his machine tools, and decrease the cutting speed.

Another noted authority wrote: "In looking over these records, it is only fair to consider, that included in them are bars from concerns in which high strength and ductility have been sacrificed, in order to secure such a character of metal, as would machine with the greatest ease, this property in these particular cases being the predominating requirement." Also "One thing is certain, that as in the case of steel, the malleable iron casting that machines most kindly, is as a rule, the one poorest in physical properties."

Theoretically it would seem probable that a high tensile strength in any metal, would increase difficulty in machining, if we consider that the tensile test consists of tearing apart the particles of iron, until the bar is fractured, and that a good part of the action, of any cutting tool, consists in a similar tearing apart of the particles of iron.

Results of Questionnaire

In order to obtain the ideas of those whose experience would qualify them as judges, we wrote a number of malleable foundries, and the replies showed considerable difference of opinions. A few quotations will suffice:

1.—"Very high tensile strength and high elongation malleable machines quite well."

2.—"Iron of 50,000 or 55,000 pounds tensile strength, with elongation 12 to 15 per cent is easily machined; 100 per cent of this iron is machined at high speed—without the least trouble."

3.—"There is no quesion but that very high tensile malleable iron will not answer for the small castings on which a great deal of finishing is done—where the quantity finished per hour is a matter of prime importance. High tensile material is a necessity for car work."

4.—"Unless we were able to do this (vary our mixture) our tool cost for machining these castings would in some cases be enormously increased."

It is rather significant that the product of manufacturers of light castings, especially those extensively machined, *as a rule* averages considerably lower in physical tests, than

that of makers of heavy castings, although both classes of castings give excellent results in service.

It is particularly noticeable that the majority of concerns which both make and machine certain lines of small castings, prefer a metal of medium low test, as they find

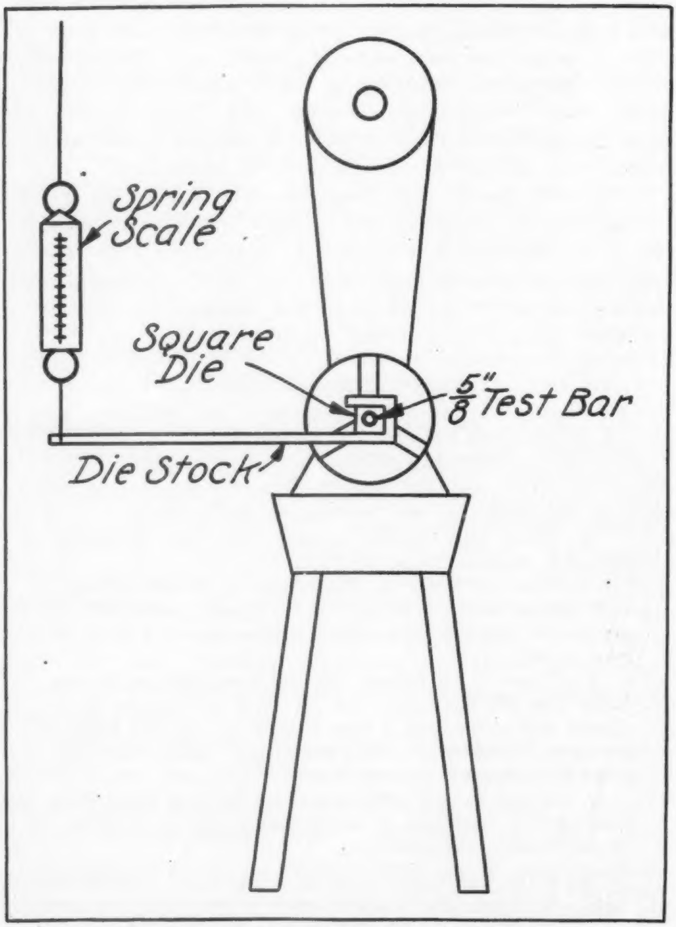

FIG. 1—END VIEW OF MACHINABILITY TESTING DEVICE

that the strength of this metal is ample, and machining qualities superior.

In view of the foregoing opinions, it seems obvious that there is need of some definite method for determining a machinability figure. It has been amply demonstrated that none of the methods for determining "hardness" gives any idea of machinability of malleable castings.

As by far the greatest part of the difficulty with high speed machining has been with the threading operations, we have endeavored to devise an apparatus to give a machinability figure, based on threading. We simply used an engine lathe, as indicated in Fig. 1. The pieces first tested were the standard ⅝-inch tensile strength bars, with one end sawed off. The remaining large end was held in the chuck. A standard die was held in a stock, and was forced on the ⅝-inch end of the test bar. To one end of the die stock was attached a rather accurate spring scale. When the chuck was revolved, a ⅝-inch thread was cut on the bar, and the pull required to cut this thread was of course registered on the scale. Giving the scale readings it is of course simple to calculate the actual pull on the die in cutting.

Samples were obtained to cover the range of 42,000 to 52,000 pounds tensile strength per square inch. Table I gives results of the first series. The speed was 27 revolutions per minute; die, U. S. Standard ⅝-inch.

Table I

First Machine Test

No.	Decarb. Depth	Tensile Strength	Elas. Limit	Elongation Per Cent	Lbs. Actual
S	0	40560	33333	7.0	794
1		47680	36220	7.0	843
N5.15-6	1/64	48000	35330	9.5	843
22		48295	34590	9.0	870
121		49490		12.0	952
N5.13-5	2/64	51870	37330	18.0	963
31425	4/64	46620	34380	7.5	979
U	3/64	50650	34950	11.5	1224
16		54320		10.0	1360

These bars were all very nearly ⅝-inch diameter, and were very free from any irregularities of surface. The results are arranged according to the ease of machining, and

it will be noted that generally speaking, the ease of machining decreases with increasing physical characteristics.

Thinking that possibly the small differences in diameter might affect results, we next selected a series of similar bars, and machined each to exactly ⅝-inch. These were threaded, results being shown in Table II; speed 27 revolutions per minute; die U. S. Standard ⅝-inch.

Table II

SECOND MACHINE TEST

No.	Decarb. Depth	Tensile Strength	Elas. Limit	Elongation Per Cent	Lbs. Actual
31418	3/64	41870	31000	7.0	625
3159	7/64	42840	31400	7.0	772
3164	5/64	40300	31710	6.0	898
31414	1/64	50120	35140	7.5	898
31526	2/64	43500	30870	7.0	918
31512		46870	31000	9.0	952
Gray Iron Bar		27370	27370	0.0	979
Cast Steel		54950	38210	10.0	1034
Gray Iron Plate					1077
31513	4/64	43720	32610	8.0	1104
3165	3/64	44210	33150	7.0	1137
Soft Steel					1496
Hard Steel					1676

In order to vary conditions, we next prepared castings with 1-inch diameter, and repeated the test, using a U. S. standard 1-inch die, speed 14 revolutions per minute. The surface of the castings was *not* machined before threading.

Table III

MACHINE TEST ON LARGER BARS

No.	Tensile Strength	Elastic Limit	Elong. Per Cent	Lbs. Actual
Gray Iron	27370	27370	0.0	1226
-1°	45740	33140	7.5	1294
1-6°	42640	32000	9.5	1310
X2-3°	41110	36690	6.0	1310
N-5.15-6	48000	35330	9.5	1134
2 8°	42060	31020	9.0	1369
1X-4°	43750	36410	7.0	1428
3X-2°	44680	34520	7.5	1453
U	50650	34950	11.5	1495
C	46550	30260	11.5	1537
N-5.13-5	51870	37330	18.0	1537
Cast Steel	54950	38210	10.0	1596

While these results show very great variations, it is obvious that on the whole, ease of machining is sacrificed to higher physical characteristics.

It seemed possible that a drilling test might throw some light on the subject, so we fitted a vertical drill press, as shown in Fig. 2. A 50-pound weight was fastened on top of the spindle, the combined weight being 65 pounds. The spindle being thrown out of feed gear, we thus had a constant pressure on the drills, all of which were 15/64-inch in diameter. The speed was 206 revolutions per minute. The results are shown in Table IV. Time to drill through ¾-inch bar was determined by stop watch.

Table IV

DRILLING TEST

No.	Decarb. Depth	Tensile Strength	Elas. Limit	Elong. Per Cent	Time Min. & Sec.	Inches Drilled	Inches Per Min.
Gray Iron Slab					3-2.0	.7559	.249
3-31425-	4/64	46620	34380	7.5	3-9.0	.7559	.240
4-31415-	3/64				3-9.1	.7559	.239
2xx-5-15-6N	1/64	48000	35330	9.5	3-11.0	.7480	.235
2-	7/64				3-16.3	.7559	.231
2x-3165-	3/64	44210	33150	7.0	3-26.5	.7911	.230
7-3149-	4/64				3-21.5	.7716	.230
4x-3159-	2/64	43500	30870	7.0	3-23.5	.7677	.226
5-3159-	7/64	42840	31400	7.0	3-26.0	.7755	.226
6-3151-	2/64				3-22.2	.7598	.225
1x-31513-	4/64	43720	32610	8.0	3-30.6	.7795	.222
5x-3164-	5/64				3-28.2	.7677	.221
3x-31515-	4/64	45480	33580	7.5	3-28.2	.7637	.220
1xx-5-13-5-N	2/64	51870	37330	18.0	3-25.0	.7480	.219
8-31414	1/64	50120	35140	7.5	3-29.9	.7637	.218
5xx-S	0	40560			3-31.2	.7519	.214
1-31418-	3/64	41870	31000	7.0	3-34.2	.7598	.213
4xx-C	3/64	46550	30260	11.5	3-36.0	.7519	.209
Gray Iron Bar		27370	27370	0.0	3-55.6	.7677	.196
3xx U	3/64	50650	34950	11.5	4-37.4	.8346	.181
Steel Soft					8-45.1	.7480	.085
Steel Cast		54950	38210	10.0	13-44.4	.7559	.055
Steel Hard					14-2.2	.7322	.052

Although we have a wide variation in physical figures, we are unable to see any relation between these and speed of drilling.

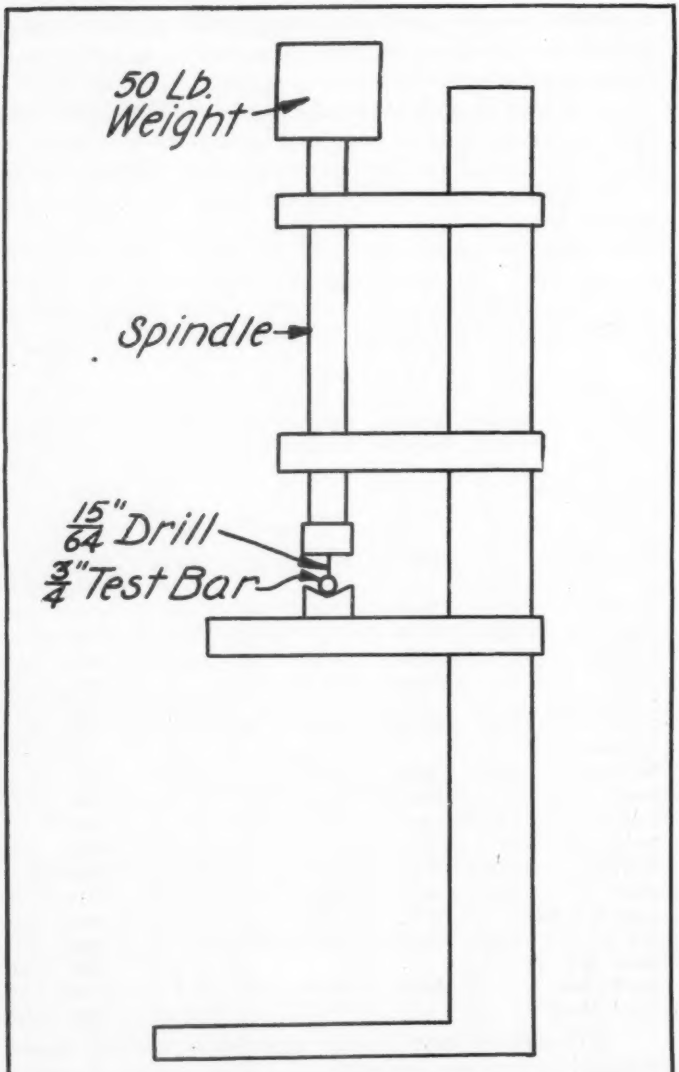

FIG. 2—DIAGRAM OF APPARATUS FOR DRILLING TEST

One point which came up in this test, and which probably has some effect on difficulty in threading high tensile, high elongation iron, was that produced by the length of chip cut. The approximate length of chip made by cutting tool is given in Table V.

Table V

LENGTH OF CHIP

No.	Tensile Strength	Elongation Per Cent	Length of Chip, Inches
C	46550	11.5	⅜
5.15-6-N	48000	9.5	2
5.13-5-N	51870	18.0	5
U	50650	11.5	6

Obviously the longer the chip, the more trouble will be caused in threading, especially on the return operation, while with any ordinary cutting work, the long chip will do no harm.

While the results of all the foregoing tests are suggestive, it is obvious that in order to be in anyway conclusive, they must be repeated, under better conditions, and we believe that a very much faster feed would give better results. As our equipment is not suited for high speed on this work, we wrote the University of Wisconsin, and have recently received a letter, stating that the mechanical engineering department would be glad to run conclusive tests on this subject in the fall. They are especially well equipped for such work, and if it can be arranged, we should get conclusive figures from their tests.

From the foregoing experiments, and from all data available to us, we can venture the following opinions:

First.—At medium speeds, all properly manufactured malleable castings can readily be machined, whether such castings are of low or of moderately high physical characteristics.

Second.—Where speed of machining is of greater importance than great strength, a metal of say 42,000 pounds tensile strength, and 6 per cent elongation will give the best results.

To our minds, a very interesting point was brought up by results on machining bars of various kinds of steel and

gray iron, as shown in tables II, III and IV. Of course too much cannot be judged from a test on a few samples, but from the figures shown we notice that:

First.—The malleable bars machine approximately as easily as the gray iron.

Second.—The malleable has almost double the strength of gray iron and an elongation of about 8 per cent as compared to no elongation in the gray iron.

Third.—Malleable castings can easily be supplied to equal this grade of cast steel in all physical tests, and to surpass it so far as smooth surface is concerned. And at the same time the malleable castings will show a superior machinability according to the operation, ranging up to that shown in the drilling test where repeated tests on cast steel showed that it required about four times as long to machine as malleable of similar physical properties.

Discussion

H. A. Schwartz.—Malleable iron consisting of ferrite and free carbon forms an intermediate link in a series of alloys beginning with ingot and wrought irons and ending with very soft gray iron. Since very soft gray iron machines, in most operations, more easily than wrought iron, it may be expected that under any given conditions malleable should be intermediate in machining quality between ingot iron and gray iron. Further the higher carbon malleables should machine more nearly like gray iron than the stronger and more ductile lower carbon malleables. So much can be taken for granted.

The question of primary concern is the magnitude of the difference in machining quality between the poorest malleable which still possesses utility and the best malleable for which there is a demand and which can be commercially supplied. A second question is how much strength can be sacrificed for a given increase in machine shop production and vice versa.

The author's quotations, apparently from Touceda, indi-

cating that malleable iron which is made purely from machining quality is usually weak, may well be understood as applying to extreme cases, primarily, and conclusions as to the differences in machineability of two very similar metals cannot be safely drawn from these statements which are made in general terms only.

A significant experience has come under the writer's observation within the past two years. Two foundries were furnishing castings from identical patterns in very large quantities to a given machine shop. Only one form of casting was bought by the manufacturers. Both foundries sold and furnished iron of standard quality (45,000 pounds tensile 7½ per cent elongation), and the product was carefully inspected in both plants by disinterested parties.

The product of each foundry was quite uniform and safely above the specifications. That of one foundry averaged about 5000 pounds per square inch, and perhaps 3 to 5 per cent elongation higher than the other. The machine shop found that the better product machined without any difficulty, while the poorer gave a good deal of trouble. Results of this nature based on the machining of many thousands of castings would seem to indicate that a sweeping statement that the stronger of two nearly similar irons will machine less readily cannot be accepted without question.

The author's statement as to the quality of product made by manufacturers of light castings is not necessarily to be ascribed only to a desire to produce greater machining ease. Small castings are usually higher in carbon and silicon in order to secure greater fluidity of metal than is permissible in large castings, hence the physical properties are not so good. It is conceivable that a casting may be used for a purpose, say a barrel bung, in which no strength is required, and accordingly it may be good practice to sacrifice everything to machining.

The striving after production at the expense of quality has, however, great disadvantages. The experience of some automobile concerns who bought details such as wheel hubs on the basis of cost and machineability has in the past been almost disastrous.

The author's threading test measures more or less accurately the pressure of a chip of definite cross section upon the point of the cutting tool. Taylor has shown (Transactions of A. S. M. E., 1907) this pressure, on lathe tools, to be independent of the form or material of the tool or the cutting speed and to be equivalent to the value $P\ D^{\frac{14}{15}}\ F^{\frac{3}{4}}$ where P is a constant for any given material, D is the depth of cut and F the feed per revolution. He has shown further that P bears no predictable relation to any chemical or physical property of the material or to its most economical cutting speed.

In view of these observations it is not surprising that the authors were unable to quantitatively correlate tensile properties with the load on their dies more especially in view of the fact that the tests are further complicated by the friction of the dies on the material threaded and by the clogging effect of chips to which the authors refer in their paper.

The tensile strengths in Table I run with two exceptions between 46,620 and 50,650 pounds per square inch; the two exceptions are at the extreme ends of the table as should be expected. That the intervening material is arranged in a somewhat haphazard order is not surprising considering the small range of variation in physical properties. On cast specimens it is very doubtful whether duplicate tensile tests from the same metal could be made alike much closer than 1500 or 2000 pounds per square inch. Certainly a foundry running on a specification of 46,600, the lowest of the series, would frequently overrun 50,600, the highest of the series. Similarly in Table II of the eight malleable samples, six are between 40,300 and 44,200 and should give results closely alike; the higher values are found midway in the machining range.

In Table III there is a somewhat better selection of material available. Numbering the malleable bars from 1 to 10 in the order of their tensile strengths the machining quality runs in the following order: 6, 3, 1, 8, 2, 4, 5, 9, 7, 10. The average of the first three is 3 1/3, of the middle four, 4¾, and of the upper three, 8 2/3, showing a progressive increase in the load on the tool with increasing tensile strength.

The only direct application of the value of *P* in the arts would be in the design of machine tools and cutters to prevent their failure by breaking off.

The value of *P* may, however, be a useful constant for checking up materials since it is easily determined. In the writer's judgment a rough relationship is shown to exist by Taylor's data to the extent that *P* is high in products machined with difficulty and low in soft ones.

Cutting Speed is Important Consideration

There is, as Taylor states, no predictable connection between the cutting speeds and values of *P*. Herbert in the *Journal Iron and Steel Institute,* 1910, has published the results of extended tests showing that the durability of the tool is fixed by its temperature. He has shown that for a given form and material of cutter and a given quality of material to be machined the durability of the tool is constant for constant values of atS^3 where a is the area of the chip, t its thickness and S the cutting speed. He has shown further that his assumptions agree with Taylor's published data. The temperature of greatest durability, i. e., the values of atS^3 for greatest durability could not be determined except by direct experiment, in general the durability first increases and then decreases as S increases. In many cases there is a second increase and decrease dependent on the tool steel conditions.

Under these circumstances it is not safe to attempt any prediction of permissible speeds of cut based on the authors' data. The observed differences in load may cause either enormous or negligible differences of cutting speed.

It is extremely unfortunate that the authors dealt so briefly with the surface conditions of their specimens. The column headed "Decarbonized" depth offers the only clue. Strictly speaking there is no such thing as an entirely decarburized depth of any great thickness, the carbon shading off gradually and sometimes more and sometimes less uniformly for the area of constant carbon at the center to the low carbon area at the circumference.

How did the authors determine the boundary between

decarburized and undecarburized metal? More important still what was the condition of any remaining carbon in the machined areas? The presence of amounts of pearlite, of cementite and of temper carbon, all equal to the same amount of carbon would be widely different in effect on machineability.

Summary

The writer would express himself as in accord with Smith and Barr's conclusions except in the case of the second statement in group one.

Table II, which indicates the most concordant results, shows that the load in the die for the three weakest irons whose average tensile strength is 41,937 pounds is 1329 pounds, while that for the other seven, averaging 46,164 pounds, is 1404 pounds. The writer submits that this difference does not raise a sufficient presumption as to machineability in favor of the weaker iron to justify the author's conclusion that 42,000 pounds iron should be adopted where speed of machining is of more importance than great strength.

The tests indicate that the stronger iron will require about 6 per cent more power in machining at equal cutting speeds, but show nothing conclusive as to what the effect, if any, on cutting speeds will be.

The writer would rather draw the conclusion that for the range of properties from 42,000 to 52,000 pounds per square inch, the machineability of malleable is more largely affected by other variables than by the tensile properties.

However, before either this conclusion or that of Smith and Barr can be regarded as definitely established a great deal of work will have to be done in developing methods of tests, studying the principles involved in the interpretation of data and investigating a much greater number of materials.

The authors have done pioneer work in a very difficult and complex problem and it is to be hoped that all interested parties will thereby be encouraged to make such investigations and publish such data as may be expected to further our knowledge.

A Note on Britain's Experimental Foundry

By G. Ernest Wells, Sheffield, England

I shall endeavor in this brief paper to give a short description of the foundry built during the war by the British government at Brentford, and the reasons which prompted the British ministry of munitions in establishing it. Primarily the purpose was to enable researches to be made into all questions affecting the manufacture of malleable iron castings. In Great Britain the output of most firms is small and the result is that with one or two exceptions, practically no producer does sufficient business to enable it to conduct the manufacture of malleable iron castings on thorough and up-to-date scientific lines.

Before the war, makers of pig iron specialized in irons suitable for use in the manufacture of malleable iron castings, and each maker used a brand or trade mark by which his iron was known. The malleable iron founder made tests of the different brands and eventually bought those particular ones which in his opinion best suited his methods.

Supplies Were Cut Off

After the outbreak of the war, many of our supplies of raw material were either cut off or sidetracked for different purposes with the result that although malleable iron founders still continued to buy the brands of iron which had given them satisfaction in the past, they found all sorts of new troubles cropping up for no apparent reason. Had all the founders been in posession of up-to-date chemical laboratories before the war, they would naturally have quickly discovered that the analysis of their material had completely changed and would have acted accordingly, but in view of the lack of facilities for carrying out this work, it was felt by the

ministry of munitions that the best thing to do was to equip a small foundry with trained technical staff, in order that the difficulties experienced should be submitted to impartial and independent investigation.

The plant erected contained an up-to-date cupola, a number of pot-holes, one or two different types of annealing furnaces, and a completely equipped physical and mechanical testing laboratory. This laboratory was put in charge of Mr. Mason, a skilled research chemist who had specialized in malleable iron problems, while the foundry itself was in charge of a malleable iron founder of considerable experience.

As the work developed, difficulties of all sorts experienced by manufacturers were put up to the government's experimental foundry for solution, and after a thorough investigation a report was made which was at the disposal of any founder who wished to see it.

Results Were Valuable

In this way a great deal of valuable work was done, and in certain cases raw materials were successfully used which hitherto had been considered valueless for the manufacture of malleable iron castings. At a later date, a good deal of help was given to firms who were experiencing difficulty in the manufacture of so-called semisteel shell, and John Shaw arranged demonstrations at the Brentford foundry so that contractors were able to send their technical men to see exactly how success was to be attained.

Report of A. F. A. Committee on Specifications for Malleable Iron Castings

Affiliated with a Similar Committee of the American Society for Testing Materials

Your committee begs leave to report as follows: The majority of the members of your committee have been constantly in touch with the work of the American Society for Testing Materials committee with whom they are affiliated in their efforts to have the tentative specifications for malleable iron castings made standard. In view of this fact it was thought it would serve no useful purpose to call a meeting for a personal discussion of the matter unless some member of the committee had in mind some change he cared to recommend.

A letter was written to each member asking his opinion in regard to the desirability of discussing the situation personally prior to our meeting in September but they have signified their desire to endorse the action taken by the American Society for Testing Materials committee on malleable iron castings and recommend to the American Foundrymen's association its acceptance of this specification as standard.

Inasmuch as the tentative specifications have been made standard there are no remarks to be made in connection with them beyond what was contained in the committee's report of last year.

Respectfully submitted,

A. E. Hammer
W. G. Kranz
F. E. Nulsen
Enrique Touceda, *Chairman*

The Elimination of Strains in Iron Castings

By C. J. Wiltshire, Schenectady, N. Y.

It is a well known fact that appreciable strains remain in iron castings after cooling, which are caused by unequal radiation of heat from the castings after they are poured. This unequal radiation is due to variation of section and difference in length of paths from inner to outer surfaces, through which the heat must pass to escape.

In consequence, the heat is not uniformly dissipated as the portions where the metal is thickest and those most remote from point of heat exit retain temperature longest, causing shrinkage strains to be set up in the parts which have been first to cool.

Some 22 years ago, Alexander Outerbridge, of Philadelphia, discovered that vibration of a cast iron bar (by tumbling in a barrel or by a continued tapping with a hammer) would invariably increase the strength of the casting. The theory of this treatment is that the action of cooling causes molecules of iron to be held in tension which is relieved when the casting is subjected to vibration.

It has since been found that this tension can also be relieved by annealing the castings in an oven of moderate temperature, which method it is the purpose of this paper to describe.

That shrinkage strains exist in most castings is demonstrated by the fact that if a plain cast-iron plate is machined to a true surface on one side, the operation of machining the other side will frequently disturb the accuracy of the surface first finished. This phase of the matter was presented to the American Foundrymen's association in a paper on "The Seasoning of Gray-Iron Castings," by L. M. Sherwin, of Brown & Sharpe Mfg. Co., at the Boston meeting in 1917.

Large castings which have been left in the sand to cool off slowly and then finished to true dimension, after a few days have been found distorted under ordinary temperature changes, but these same castings after treatment in the oven did not show any change whatever.

Results of Annealing

Other castings which have been finished and put under steam for test have shown considerable distortion when taken apart, while castings from same patterns when treated in an oven before finishing and tested out in the same way, showed absolutely no distortion.

Again, large castings which have been finished and lined up as parts of a large unit, after a number of months in service have shown sufficient distortion to cause parts of the machine to become out of line. Such castings are now being annealed and from results obtained it is believed that this treatment will prevent the defects experienced.

The method of treatment is as follows:

The castings are placed in the oven, the doors are closed, the heat turned on, and the temperature raised to 700 degrees Fahr., which generally takes from seven to eight hours. This temperature is held for an additional seven hours, when the heat is shut off and oven is allowed to cool down slowly for approximately 20 hours, with a resulting temperature of about 300 degrees Fahr. The oven doors are then opened and temperature is allowed to drop to approximately 150 degrees Fahr., when the castings are in shape to be taken out. The entire operation consumes about 48 hours.

The ovens are heated with oil and the amount of oil per ton of castings treated has averaged 9.6 gallons. Each heat required 284 gallons of oil and approximately 29 tons of castings were treated each heat.

Discussion—Eliminating Strains in Iron Castings

Mr. Asa W. Whitney.—The method of annealing for the relief of strains only, not for the radical change of structure as accomplished in annealing white iron at high temperature, is applied to soft iron castings almost exclusively after the castings have wholly cooled and strains and distortions have become very serious.* For many classes of castings this method is perhaps the only feasible one and the data given by Mr. Wiltshire as to temperature, time, oil consumption and the method of cooling, are of interest as establishing records on those points.

The long time, seven to eight hours, occupied to heat to 700 degrees Fahr. is probably partly due to the inability to heat a mass of cold castings evenly in any internally fired oven, if the flame is applied too severely. Undue haste causes uneven heating and cracks or strains many castings.

But it seems to the writer wholly unnecessary, though harmless, at the low temperature used and for soft iron castings, to take as much as 20 hours to cool from 700 degrees Fahr. to about 300 degrees Fahr. Very properly there is no draft allowed through the furnace in this cooling, but the cooling from 700 degrees Fahr. could probably be done safely in four to five hours if it is worth while to construct the furnace to this end. In such case, the whole time of heating, soaking and cooling could be reduced to 33 hours. However, unless the time could be reduced to about 22 hours the same furnace could not be used for daily heats.

Whenever possible the car wheel maker's idea seems more sensible, scientific and economical. Their aim is to properly control the original cooling of the casting from as high a temperature as admits of handling the casting without mechanically straining it, say between 1553 degrees Fahr. (light cherry red)

to 1175 degrees Fahr. (dark cherry red). In this way, all strains except those caused by the chill ring in car wheel practice are largely prevented and, with modern chill rings, the latter are minimized.

However, the general method by which wheelmakers carry out their idea is not only inefficient in relieving strains for certain patterns, for wheels delivered to the pit too cold, and for certain compositions, which are the best if properly annealed, but, because of the massed construction of pits and the consequent four to seven days required to cool, though no fire is used, the common practice actually damages the structure of the metal by enlarging the grain size, increasing the graphite size slightly, coarsening the pearlite structure and producing minute spots of partially graphitized pearlite in the chilled portion. The result is far more irregularity of strength and lower mileage than can be produced by a proper technique of annealing. Moreover, proper annealing admits the use of harder and more suitable compositions and microstructures as shown by comparing Figs. 1 and 2.

In 1847, the writer's grandfather, Asa Whitney, introduced preheated 66-hour pits and in 1898 the writer developed 42-hour oil-fired annealing pits designed according to the principles of proper heat treatment of castings, as applied before the casting temperature is dissipated.

As a result of long experience with the 66-hour and 42-hour pits, the author has been able to produce wheels from which extraordinary mileage has been obtained. In direct service tests under the tender of a switch engine in a very severe service where wheels had failed in 10,000 to 26,000 miles, wheels from the 42-hour pits gave over 126,000 miles, although made in a shop equipped only for making lumber and mining car wheels. They were made of coke, pig iron, steel and miscellaneous scrap, the metal not being dosed with alloys in ladle. The wheels were cast in contracting chillers, annealed in preheated pits and removed cold in 42 hours. (See Plate 13 of "The Metallography of Steel and Cast Iron," Howe, 1916.)

Before the wheels were worn out, the writer prepared an article on chilled wheels which appeared in December, 1912, in

FIG. 1—HIGH CHILL WHEEL WHICH IF ANNEALED PROPERLY WOULD HAVE GREATER STRENGTH AND DOUBLE THE MILEAGE. (300 DIAMETERS)

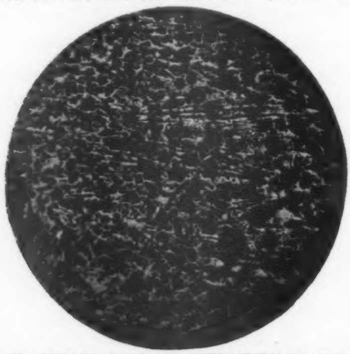

FIG. 2—¼-INCH BELOW CHILLED FACE OF OVERANNEALED CHIP OF CHILLED PART OF WHEEL MIX. BEFORE THE LABORATORY ANNEAL THE CHILL WAS AS FREE OF GRAPHITE SPOTS AS THE PIECE OF WHEEL SHOWN IN PLATE 13, "THE METALLOGRAPHY OF STEEL AND CAST IRON," BY HOWE. (30.5 DIAMETERS)

the *Whitney Magazine* of the University of Pennsylvania, Asa Whitney long ago having endowed the chair of dynamic engineering there. The following is from the article:

"Asa Whitney had proved to his own satisfaction that any desirable pattern of car wheel or other chilled casting could be properly annealed only by placing the red hot castings in a preheated pit, and, instead of relying on the slow cooling of the mass, actually raised its temperature by furnaces whose heat could go so far as to decompose the chilled treads into a sort of malleable iron. He had proved that by proper heat regula-

tion no such damage would occur, and that by proper construction of the pits the high temperature could be quickly attained, briefly maintained and rapidly reduced. His pits, 48 in number, and 18 feet deep, were emptied after 66 hours, the wheels then being no hotter than could be rolled to cleaning shop by men wearing hand leathers."

The writer's pits of 1898 were not dependent on a cooling air draft through the mass of castings, but carried out Asa Whitney's principle more thoroughly and in less time by greatly increasing the external radiation of heat, as soon as the fire was shut off and pit sealed. This is as important as the rapid heating.

In the writer's practice medium and light wheels were charged as hot and fast as possible. The temperature was raised about 400 degrees Fahr. from an average of 1100 to 1500 degrees Fahr. in 1¼ hours or less. The total time of application of oil fire was about 3¼ hours, being preheated for about two hours. In a 12-heat test of one pit used daily, the alternate pit cooling, two net tons hot wheels were heat-treated by 5.6 gallons of residium oil at 5¼ cents per gallon or nearly 15 cents per ton. The pits held 3½ net tons, but were used with an average of only 2 tons at this time.

Cold castings, especially if hard or under strain, must be heat treated slowly, but hot castings can be and should be heat treated rapidly to avoid damage if structure is already nearly right. For the same reasons hot castings usually should be and actually can be cooled rapidly to retain structure and avoid coarsening it, because there are no unrelieved strains engendered by a previous cooling. The only requirement seems to be, as in the case of glass annealing, that the time-temperature "curve" should be a straight line, or nearly so, for any and all parts of the casting. This precludes cold air draft being used at all for rapid work. And, as usually in cast iron the finest original structure should be preserved, the time-temperature curve must be as steep as possible, that is, the time must be short.

The Electric Furnace as an Adjunct to the Cupola

By George K. Elliott, Cincinnati

This paper is a sequel to one read by the author before the American Electrochemical society last April. In that paper, entitled "Improving the Quality of Gray-Iron by the Electric Furnace," the author described a duplex process for making gray iron suitable for the demands of modern engineering for super-grades of iron castings. The duplex process described was one installed at the plant of the Lunkenheimer Co. at Cincinnati, where it has been in successful operation for a number of months. The process consists simply of using in tandem the ordinary foundry cupola and the arc electric furnace. The purpose of the present paper is to re-emphasize the significant fact that cast iron as it comes from the cupola furnace has serious limitations that are being brought to light by the more extreme demands of modern engineering progress, and that the arc electric furnace is a competent supplement to the cupola for producing cast iron of superior quality.

Cupola Noteworthy Success in its Field

Before proceeding into his subject, the author desires to make it plain beyond all possibility of misunderstanding, that his attitude toward the cupola furnace is not one of hostility nor is his criticism destructive. On the other hand, he is decidedly friendly to the cupola and his intentions are entirely constructive and calculated to be helpful and co-operative. He would not have it even suspected that the cupola is losing its long and honorable prestige, because, in truth, he knows there is no reason why it cannot continue indefinitely to be what it always has been, the most serviceable melting furnace known to foundry practice. For the ordinary run of iron castings, comprising possibly 90 per cent of the total output, there

is no valid economical reason for either displacing or radically modifying the modern cupola. It is a noteworthy success in its accustomed field. It is only here and there in engineering, probably scattered throughout all its many branches, that we find the advanced ideas of the designing engineer not adequately matched by the best product of the iron foundry.

The result of this gradual unveiling of apparent disability in some iron castings is that the material itself is receiving a growing amount of arraignment and rebuff which we see clearly reflected in the tendency of certain specifications to pass over cast iron and seek malleable or steel castings. Far be it from us to say that some of these cases are not entirely justified by the intended service, but we do venture the opinion that in very many of them, gray cast iron as it is at its best, is preferable to the substitutes demanded. There is in gray cast iron a certain maximum worth and definite characteristics that are seldom developed to the fullest extent in the average iron foundry. We refer to the super-qualities of our best grades of pig iron, when melted, refined, superheated and cast by the best possible methods. In other words, cast iron when done full justice in the foundry, is a much better metal than even its best friends are accustomed to proclaim.

We believe that the average modern iron foundry is making castings that realize the best that is possible to their equipment but not the best that is possible to the iron itself. Foundry equipment, therefore, is at fault in its failure to realize all the innate worth of cast iron; and not the least offender is the cupola furnace. The function of the cupola is to deliver iron molten and ready for the molds, and this it does, economically, with great regularity, and continuously as long as wanted. It is a wonderful foundry servant but like its human parallels, it has sharp limitations.

Melting Efficiencies of Furnaces

Whatever its faults may be, it must be acknowledged that for preheating iron up to the point of melting, and after that performing the fusion itself with a minimum waste of heat, the cupola stands supreme among the established foundry furnaces. Its melting efficiency approximately is 40 per cent although in

the hands of the unskilled it may fall as low as 25 per cent, while the adept may drive it along at a rate of as high as 50 per cent efficiency. Counter to this we have an average efficiency of about 12 per cent in the reverberatory or air-furnace, and of about 25 per cent in the open-hearth regenerative furnace. The improbability of the popularity of the cupola furnace ever waning to any decided extent is well set forth in these comparative efficiencies.

Although the cupola is practically without rival as a preheater and melter it does not attain the same high rank as a superhearter of molten metal. Here is the first glaring weakness of the cupola. It never fails to melt iron, but at times it fails to superheat sufficiently for the best results. In many cases, the super-grades of castings referred to in this paper, demand very hot iron, in fact iron hotter than seems to be uniformly possible in the cupola. However, in many instances the cupola is in the hands of extremely clever,experienced and intelligent masters who, by taking advantage of every circumstance of furnace, fuel and iron, succeed, to a limited but quite remarkable degree, in forcing the cupola to do what it constitutionally is not fitted to do—to produce molten iron with a fairly high degree of superheat.

Difficulty of Superheating in Cupola

The cupola operator's problem in obtaining superheated iron is largely one of circumventing terrestrial gravitation as it is manifested in the speedy dripping of the molten iron through and away from the hottest zone of the cupola. Gravitation makes possible the simplicity of operation of the cupola furnace, and it seems to the author that it is the chief cause of the furnace's inability as a superheater. It removes the iron, once it is melted, too rapidly from the zone of maximum heat in the cupola; it curtails the time available for heating and robs the liquid iron of its best opportunity for acquiring a large degree of superheat. This is the main point in cupola operation to challenge the skill of the melter.

In the two-step process that has been described, all responsibility for superheating is taken from the cupola and assigned

to the electric furnace, where with the greatest ease it can be superheated to a degree that is not possible in any other kind of furnace. Temperatures possible in the arc electric furnace which is recommended for this process are limited only by the melting point of the refractory lining. By this we do not intend to intimate that the higher temperatures available in the electric furnace are to be sought for cast iron, as this is far from the truth. Attaining them would be a sad waste of power with no recompensing advantage. In general, an additional one hundred or one hundred and fifthy degrees Fahr. over its cupola-given temperature is all that is necessary for gray iron.

Superheating Allows Use of Low-Phosphorus

The natural question to be raised at this point concerns the advantages accruing from extra hot iron. The most apparent are those having to do with the perfect running out or reproducing the impressions in the mold. Castings of thin section and large general dimensions are important in this consideration. Many castings of this kind are made of high-phosphorus iron merely because of the increased fluidity obtainable only through excess of phosphorus. This practice is followed in spite of the fact that phosphorus detracts substantially from the strength of the castings, reducing especially their ability to resist shock and vibration. Superheating in the electric furnace enables the foundryman to make these castings of low-phosphorus iron because he can safely shift the responsibility for fluidity from the material to the furnace. The possibility of casting strong tough irons in thin sections is one of the great advantages of highly superheated metal.

Hot Iron Increases Solidity

Another advantage, and by no means a minor one, is that hot iron tends to increase solidity in castings. By solidity is meant not only closeness of grain but freedom from internal imperfections such as blowholes, shrink-holes, slag inclusions, graphite segregations, and similar defects. The close relation existing between solidity and hot pouring temperatures is not always a matter of great concern, but to some foundry-

men it is, especially to those unlucky ones whose castings are put to some form of rigid test for solidity. The makers of hydraulic cylinders and valves for high pressure steam are in this class. These men are convinced that hot iron and a low percentage of leakers on the test, are related one to the other as cause and effect. They are interested in hot iron to a degree that seems fanatical to their brother foundrymen.

It should be made clear that what is termed cold iron in this paper is not necessarily iron that is downright sluggish in the ladle but rather iron of a temperature above that point and still below the temperature necessary for the very best results. Cold iron may be too viscous to allow the escape of entrapped inclusions of gas which constitutes a most fruitful source of blowholes. Also iron is cold that freezes in the risers before they have completed their function of feeding the casting, especially of feeding it during that most critical period when the conditions tending to what Longmuir has called "liquid contraction" are at the height of their power. Improper feeding is one of the harmful results of lack of superheat.

Tests on Iron Poured at Various Temperatures

The subject of Longmuir's liquid contraction is most attractive and is distinctly pertinent to the subject of solid castings. The name was coined to describe the local contraction that takes place in the heavier parts of a casting immediately after the solidification of the outer surface. Its close relation to casting temperature already has been suggested. Two excellent papers on the subject have been written by Hailstone and published as Carnegie scholarship memoirs by the Iron and Steel institute of London, one in 1913 and the other in 1916. They contain descriptions of the results of experimental investigations of liquid contraction. Gray iron of common variety poured at temperatures between 2527 and 2602 degrees, Fahr., which may be classified as very hot iron, gave solid castings of close grain and maximum strength. The same iron poured at progressively lower temperatures became weaker and more open of grain in direct proportion with the decrease of the casting temperature. When poured at 2458 degrees Fahr.

and lower, liquid contraction in the form of cavities in the heavier parts was apparent, while blowholes appeared when the pouring temperature of 2376 degrees Fahr. was passed. It also was found in these experiments that the specific gravity of the castings varied from 7.281 in the iron poured at the highest temperature to 6.936 in that poured at the lowest temperature (2307 degrees Fahr.). The results here reproduced were secured by Hailstone, using what he called "iron of the common variety" and they verified similar results which he previously had secured with "iron of the better variety." The experience of this British metallurgist has been borne out in at least one American foundry specializing in castings of great density. The high temperatures giving the best results in the experiments just mentioned, are not temperatures ordinarily and consistently attained in the cupola except possibly in a few anomalous instances. On the other hand, they can be attained after a half hour's superheating in the electric furnace.

Electric Furnace Adapted for Malleable

Another place where electrically superheated iron is of value is in the wide field of white irons. Naturally this should have its widest application in iron suitable for malleablizing. The possible benefits here are great. The freezing of molten white iron before perfectly running out the molds of smaller castings, and freezing in the ladles are no infrequent occurrences in the average malleable foundry. The infant mortality among small malleable castings in this way is appalling. The chief cause lies in the fact that the temperature and time range of workable fluidity for white iron is much narrower than for gray iron. The fact is, the temperature of gray iron can drop nearly twice as far before freezing as it can for white iron, which means that the time available for handling white iron is about half what it is for gray iron. The use of the electric furnace corrects this great trouble, because the iron it delivers to the molder is sufficiently fluid and hot to be poured without "skulling" the ladles and with losses of castings through misrunning lowered to the minimum.

The process of treating iron in the cupola cannot be extended beyond the point of melting and a certain limited amount of superheating. Any additional operation such as refining, is entirely out of the question and can be performed only in some other kind of furnace. The cupola is not a refining furnace. However, it often happens that from the double standpoint of raw material and product, a certain amount of refining is desirable and even necessary. Refining is the principal foundation upon which is built the reputation of the electric furnace as a metallurgical apparatus, and it is truly claimed that from even the cheapest raw materials the electric furnace can produce steel of the highest quality. With no less truth, the same can be said of preparing cast iron in the electric furnace. Essentially the electric furnace is a purifying furnace and certainly it supplies the very complement that the cupola furnace most needs.

Electric Furnace as a Refiner

In considering the electric furnace in relation to refining it is preferable to consider separately the acid-lined and the basic-lined furnaces. The acid-lined furnace is simpler in operation but also much less efficacious as a refining unit. It refines entirely through maintaining a constant reducing atmosphere in contact with the metal. The refining in an acid furnace is one of deoxidation coupled with a freeing of the bath from included gases and slag. However, the acid-lined furnace is hardly to be compared with the basic for refining, and its use in a duplex process should be for plain superheating and for mixing, but not where any considerable degree of refining is desired.

One must turn to the basic-bottom electric furnace to find potentiality in refining at its greatest. The possibilities of this furnace are bounded only by economical considerations. Almost any metallurgical reaction may be conducted in it, including oxidation, reduction, dephosphorization, desulphurization, decarburization, carburization, mixing with ferro-alloys, superheating, and others. The duplex process for cast iron is chiefly concerned with reduction, desulphurization and mixing.

Normally, the conditions in the electric furnace are strongly reducing and the exposure of cupola melted iron to them seems to have a distinctly beneficial effect. Whether iron can be oxidized in the cupola under ordinary conditions is a question upon which the authorities are not all agreed nor is there unanimity of opinion as to the benefit or harm of oxygen in cast iron. Personally, the author believes a deleterious oxidation can at times occur in the cupola, and his experience strongly indicates that cupola iron thoroughly deoxidized as it is in the electric furnace, exhibits an improvement in general physical properties that is hard to account for on any other grounds than of deoxidation. Also it is his experience that thoroughly deoxidized iron has perceptibly more life than has the untreated iron at the same temperature.

Desulphurization in Electric Furnace

Desulphurization is an extremely satisfactory reaction when performed in the basic electric furnace. It is not only easy to perform but it takes place during the same time that the iron is being superheated, involving no extra consumption of power. Another factor tending to fit the operation into this process is the fact that desulphurization depends for its success upon maintaining reducing conditions in the furnace. The chemical reaction by which the sulphur is removed is essentially as follows:

$$FeS + CaO + C = Fe + CaS + CO.$$

From this reaction it is seen that carbon is essential to its completion and therefore the large amount of carbon in the iron, and the carbon electrodes themselves, have a most beneficial influence upon the removal of sulphur from the bath. It is understood that the necessary basic slag is present in sufficient quantity and of the proper quality.

Sulphur is unavoidable in cast iron made by the usual methods and it is the custom to pass it over as a necessary evil. If the bare truth be spoken, the only good that can be said of it is that sometimes it is of assistance to the founder in obtaining chilled castings. The damaging fact about sulphur is that whether united with iron or with manganese in the form of sulphide, it composes an insoluble, non-metallic structural

component in cast iron that cannot do aught but unfavorably affect the good physical properties of the metal.

May Reduce Sulphur to Low Figure

Standard pig iron containing a maximum of 0.05 per cent, sulphur contains from 0.07 to 0.11 per cent after coming from the cupola, the degree of contamination depending upon the quality of coke, the condition of the cupola and its accessories, and the skill and knowledge of the cupola tender. The same iron from the cupola may subsequently have its sulphur reduced to about one-third or one-fourth by 30 or 40 minutes refining in a basic bottom electric furnace. The average of a great number of "duplexed" heats of gray iron was .088 per cent sulphur in the melt from the cupola, while in the final product from the electric furnace the average was 0.036 per cent. As low as 0.009 per cent sulphur in occasional heats has been produced in gray iron under everyday working conditions.

The economical side of this great power of desulphurization attracts the attention. The founder who is able to employ this process with the basic furnace immediately finds himself to a large extent emancipated from the tyranny of low-sulphur specifications in the selection of raw materials, including pig iron, scrap and coke. The advantage is great and must be apparent to all. According to metallurgists of the iron foundry there exists today a sulphur problem which bases its gravity upon the probability that constant melting and remelting of the iron scrap of the world is causing a steady increase in the sulphur content of iron castings made from even the smaller percentages of scrap iron. Coke also is involved and the duplex process described does not necessitate the use of low sulphur cokes which not always are easily obtained. The doors of many foundries are closed to "off" grades of pig iron because of the high sulphur brand of shame attached to them. Here the basic electric furnace is a great leveler which makes high or low sulphur irons almost equally acceptable.

We have said that the electric furnace step of the duplex process is particularly good for mixing. It enables a perfect

mixing of the original raw materials, assuring homogeneity in the single heat, and it facilitates the accurate duplication of results, assuring uniformity among several heats. It simplifies and insures the perfect admixing of alloys such as ferrosilicon and ferromanganese. In the case of the latter, it is especially valuable in view of the considerable loss of manganese that is inevitable in the cupola. Under the reducing conditions prevailing in the electric furnace there is absolutely no loss of manganese. Steel scrap may be admixed in the electric furnace making attainable that carbon-diluted form of gray iron which is also known as semisteel. This method indeed produces a real alloy of gray iron and steel with the total carbon capable of the closest regulation, and the dream of the semisteel enthusiasts is realized as by no other method.

In concluding, the author would like to leave two injunctions concerning the use of the electric furnace as an adjunct to the cupola. In the first place, the duplex process just described is not intended to displace the established methods of preparing iron in the cupola for ordinary grades of iron castings; certainly they will not bear the added cost. The process is intended, however, for those extraordinary cases where ordinary iron as produced by the ordinary process has not met the demands of the occasion and where the advantages gained justify the extra cost of production. Also, the author does not claim that the electric furnace presents an infallible cure-all. Its adoption cannot be expected to release the founder from the necessity of good foundry practice and of constant, experienced and intelligent metallurgical supervision in every department of the foundry establishment. The electric furnace is but a bit of apparatus, efficient, it is true, and in some ways almost wonderful, but it must be supplemented by human brains.

Discussion

Dr. Richard Moldenke.—We are going to get all the castings made during the war back in the scrap pile before 20 years have passed and we will get scrap with up to 0.32 per cent sulphur. The question is what we are going to do with

material so full of sulphur—although sulphur is not so dangerous as we once thought it was. Mr. Elliott has found that the basic hearth electric furnace will be the solution for the high sulphur trouble. I have tried to overcome the sulphur problem but so far have failed. The last experiment I made was by blowing hydrogen through the molten metal to reduce the sulphur and deoxidize the metal at the same time. I nearly blew the place up and got a perfectly hard white iron out of gray pig. In the basic electric furnace you have the lime or magnesia bottom, which is ready to take up sulphur if you have the temperature high enough; and so Mr. Elliott has reduced the sulphur to almost nothing by melting the metal in the cupola in the ordinary way and finishing in the electric furnace. The only drawback is the high first cost of an electric furnace plant. With castings costing you from 15 to 18 cents a pound in your own shop, it does not hurt to add another ½ cent a pound by making them in the electric furnace. Where you have a casting costing you 4 cents a pound in your shop, you cannot add another half cent. Therefore the electric furnace will be popular for higher grade work, such as piston rings, etc., where you can afford to add a little to the cost to obtain molten metal yielding extra good results.

A MEMBER.—I would like to ask if Dr. Moldenke has had any experience in the use of cast iron borings in the electric furnace.

DR. MOLDENKE.—I have not had any experience myself, but I think that in the basic electric furnace you ought to get first class results. The idea is that the electric furnace has heat enough for complete deoxidation and then the results will be all right.

MR. GRAGAN.—I have had a little experience with a carbon bottom electric furnace for melting scrap and converting it into gray iron. I used a 500-pound furnace, and with 85 per cent coke and 15 per cent pitch and by putting in a carbon bottom, I am now melting turnings and borings, both of steel and iron, and getting gray iron castings.

The Side Blow Converter in the Iron Foundry

By George P. Fisher, Harvey, Ill.

Statistical reports of the American Iron and Steel institute, classifying the steel castings produced in the United States according to the process used for melting and refining, contain the following production figures in gross tons for 1916 and 1917:

	1916		1917	
	Gross Tons	Per Cent	Gross Tons	Per Cent
Open hearth	1,176,449	85.76	1,213,156	84.16
Converter	142,791	10.41	159,272	11.05
Crucible	9,351	0.68	3,834	0.26
Electric Furnace	42,870	3.12	64,911	4.50
Miscellaneous	302	0.03	234	0.02
Total	1,371,763		1,441,407	

At the date of this paper the figures for 1918 have not been published.

Each of the three principal processes for the manufacture of steel castings has advantages and disadvantages as compared with its rivals, and each has its own separate and distinct field of operation. As shown by the above figures about 84 per cent of the tonnage of steel castings is credited to the open-hearth furnace, 11 per cent to the converter, 4½ per cent to the electric furnace and 0.5 per cent to the crucible and miscellaneous.

Any foundry proposing to manufacture steel castings must consider which process will prove most economical and satisfactory for its particular class of work. With a proper selection of raw materials and the requisite amount of care and skill, good castings can be produced by all three processes,

and it is equally true that without proper care and skill very poor castings can be produced by any of the processes mentioned.

The Field of the Open-Hearth Furnace

Practically all heavy castings, by which we mean those weighing from 500 pounds up, and having sections of ½ inch or more, are cast from open-hearth metal. Where large tonnages are desired and where the sections of metal permit the use of relatively cold steel, without excessive loss due to misrun castings, this process is usually the first choice. It is considered essential for economical operation that the furnace be operated continuously for 24 hours per day and when conditions permit this, open-hearth steel can be made at a lower cost than steel by any other process. An open-hearth shop requires relativly more floor space per ton of castings produced because the heats are larger and are tapped at less frequent intervals.

The Production of Small Castings

Steel foundries are classified roughly as those specializing on heavy work and those specializing on small light work. In the latter class we invariably find the electric furnace or the side-blow converter. These two processes practically monopolize this field because of the extremely high temperature attainable in the melted metal by either of them. With either the electric furnace or the converter no difficulty is encountered in tapping steel at from 3000 to 3200 degrees Fahr., which permits the manufacture of castings weighing as little as 2 to 3 ounces each, and having sections as light as ⅛-inch. The modern steel foundry specializing on light work accepts orders for castings which used to be considered too small and intricate for any but malleable foundries.

Electric Furnace

The arc-type electric furnace has become an important factor in the steel casting industry since 1915, during which

year 23,064 gross tons of steel castings were made in electric furnaces. Furnaces of this type are able to produce metal of sufficiently high temperature to cast the lightest and most intricate castings, and can be operated with either basic or acid linings. Because of their neutral nonoxidizing atmosphere they can use very light scrap or even steel turnings. A few electric furnaces are known to be charging 100 per cent scrap and borings, and all of them are using a very high percentage of old metal, probably 85 per cent or more.

A very high degree of metallurgical skill is necessary for the successful operation of an electric furnace, and for economical results the furnace should make steel continuously for 24 hours per day. Only by continuous operation can reasonable power costs be maintained, and the cost of power is one of the most serious considerations in producing electric steel. Even when it can be obtained at as low a cost as 1 cent per kilowatt-hour, the power cost per ton of metal melted, with good practice, is in the neighborhood of $6.50 to $7.50. With poor practice the costs are very much higher. Electric furnace manufacturers publish figures showing that electric furnace metal can be produced at a cost about on a par with open-hearth steel and about 1 cent per pound lower than converter steel. These figures no doubt hold good under conditions of continuous furnace operation and cheap power rates, but certainly are reliable only under such conditions. The initial investment for an electric furnace plant is considerably greater than for a plant of corresponding capacity using either the open-hearth or the side-blow converter.

Advantages of the Side-Blow Converter

The side-blow converter is in operation in about 100 steel foundries in the United States. It has been used for the manufacture of small steel castings for nearly 20 years and the production of castings has increased from 14,000 tons in 1903 to 159,000 tons in 1917. Only the electric furnace can compete with the converter in producing temperatures which permit the casting of very light sections and small intricate shapes.

The great advantage of the converter over all other processes lie in its great flexibility, ease of operation and small initial investment. It can be placed in operation on an hour's notice and can produce 20 heats per day or only two or three at practically the same cost per heat. Heats are blown in from 12 to 15 minutes each. When not in operation it requires no attention and the only costs against an idle converter are depreciation and interest on investment, both of which are negligible. The heats are small and produced at short intervals, permitting floor space to be used over several times during the day.

The usual charge in converter practice consists of 40 to 50 per cent of pig iron and 60 to 50 per cent of scrap. The author has seen a converter operated successfully on 100 per cent of steel scrap by adding ferrosilicon to bring the silicon content to the required figure. Because the converter must be operated with an acid lining, it is necessary to purchase raw material having a low phosphorus and sulphur content.

The Side-Blow Converter in the Iron Foundry

Many plants operating an iron foundry have a demand for steel castings. Where this demand is intermittent and not for a large tonnage, the side-blow converter is an ideal installation. The melting equipment for the gray iron foundry and for the converter steel foundry is the cupola, which is already installed. When steel is required the metal can be melted in the same cupola ahead of the gray iron mixture. The converter occupies very little floor space and requires no attention when idle.

In the case under discussion we are assuming a demand for a small tonnage and in this case initial investment is worthy of serious consideration. The converter can be installed and put in operation for approximately one-sixth of the cost of an electric furnace and one-half to one-third the cost for an open-hearth furnace.

Perhaps the most important factor is the ease with which a converter can be operated. It is unnecessary to employ a high-priced furnace operator who is of little or no use when there is no demand for steel. The foundry foreman or any intelligent employe can be trained in a very few weeks to operate a converter and produce good steel. If only two or three tons of castings are required per day the time necessary to blow the steel takes perhaps an hour per day of the foreman's time, which interferes with his regular duties to a very small extent.

Because of the speed with which steel can be produced and the high temperature of the metal it is possible to accumulate two or three blows from one converter in the same ladle to pour an occasional large casting. This is impossible by any other process for making steel and is a great advantage in a shop where it is impossible to predict what size of casting will be demanded. While large castings weighing several tons each can be made as just described from a 2-ton or even a 1-ton vessel, the converter finds its greatest application in the manufacture of small and very light-sectioned castings.

Cerium in Cast Iron

By Dr. Richard Moldenke, Watchung, N. J.

The presence of oxygen in the form of a dissolved iron oxide in cast iron is now accepted as a well established fact. With good pig iron and scrap and intelligent melting practice, the percentage of oxygen involved is so small that it becomes practically negligible; but after all, the art of founding has its limitations, and the introduction of a lot of burnt grate-bars into the cupola charges by the class of men usually entrusted with this important work, may mean a very perceptible oxygen content with its attendant troubles.

While, therefore, the foundryman should seek to avoid the introduction of oxygen into his metal, accidents in practice or a general insurance against oxidation troubles make it highly desirable to have at hand deoxidizing media which can be applied readily and effectively.

Where molten iron is to be deoxidized in the ladle the best form of material to use is undoubtedly that of a granular ferroalloy. The affinity for oxygen of such metals as aluminum, magnesium, manganese, etc., is such that during the melting and alloying much may be lost by oxidation in the air before entering the molten metal to be treated. This accounts for the use of the ferroalloys of these elements. Indeed, the melting point of some of the elements suitable for deoxidation purposes is so high that unless alloyed with iron they could not be introduced into molten cast iron at all. On the other hand, the melting point of such easily oxidized metals as magnesium and sodium is such that alloying them with molten iron is a pretty dangerous operation.

How to Add Ferroalloys

In adding a ferroalloy to a ladle of molten iron the best method is to sprinkle the granulated material on the stream as it issues from the cupola or furnace spout. The alloy be-

comes red hot by the time it enters the ladle and assimilates readily. Putting lumps of material in the bottom of the empty ladle, or introducing them after the ladle has been filled always permits of some oxidation and consequently loss of the usually expensive alloys, as they will float on the surface until melted and absorbed.

Until recently the best known deoxidizers were silicon and manganese in the form of high percentage ferroalloys. Ferrotitanium and ferrovanadium are more powerful in their action; the former is more particularly useful for steel on account of its high melting point. Aluminum is very useful also but unless it is pure it may produce bad consequences. Magnesium and sodium as ferroalloys are still too unknown in the foundry to count.

A recent addition to the list is the metal cerium. As it melts at 1180 degrees Fahr., its ferroalloy lends itself readily to assimilation in molten cast iron. Since cerium until recent years was considered a chemical curiosity, a few facts about its properties will be of general interest.

What Cerium Is

The general source of the metal is in the Monazite sands of Brazil and India. These sands are worked up for their Thorium content (running up to 6 per cent in the Brazilian and 9 per cent in that from India); the nitrate of this metal is used in the manufacture of gas mantles. Monazite sands also contain about 60 per cent of the oxides of the rare earth metals, principally of the cerium group. This group also includes the rare elements lanthanum, samarium, and neo and praseodymium. In addition there is a small percentage of yttrium. These elements are obtained in the residue from the preparation of the thorium nitrate, and in the subsequent chemical and electrolytic processes used they enter the cerium alloy forming what is known as misch metal. The composition of this misch metal usually is 50 to 60 per cent cerium, 25 per cent lanthanum and 15 per cent didymium, samarium, etc. There will also be about 1 to 2 per cent iron present.

The chemical and physical properties of these rare metals are very similar, so that the mixture as above given will

accomplish everything that may be expected of any one element. To separate them, except the cerium, would prove impracticable commercially. While the melting point of cerium is reasonably low, those of the concomitant elements are considerably higher. The melting point of the misch metal may therefore be taken at about 1380 degrees Fahr. In actual practice this alloy is further diluted with iron to the extent of 30 per cent, so that the melting point of the alloy as added to the molten iron in the foundry is about 1480 to 1650 degrees Fahr., or well within the melting point of cast iron.

The cerium alloy known as misch metal is soft graying-blue in color and quite stable in perfectly dry air. It tarnishes slowly in moist air. It alloys readily not only with iron, but also with nickel, copper, magnesium, zinc, etc., and hence can be united with any of these for introduction into the respective nonferrous alloys as well as into steel and iron. When made into an alloy of 70 per cent misch metal and 30 per cent iron, it is known as an exceedingly valuable "pyrophoric alloy" and is used in the manufacture of ignition devices of various kinds, used in safety lamps, cigar and gas lighters, etc.

Active Chemically

The cerium group of metals is exceedingly active chemically. They have a very great affinity for oxygen, and the heats of formation of the oxides run in the range of those for aluminum and magnesium. The result is the liberation of great quantities of heat besides the scavenging action on the metal into which the cerium alloy is introduced. This, besides purifying the metal before pouring, prolongs the "life" or fluidity of the metal very appreciably. It may therefore be expected that castings will be softer and more dense, as feeding through the gates and risers is prolonged and the formation of combined carbon is retarded correspondingly.

The tests mentioned below were made with gray and chilling irons, with varying proportions of the cerium alloy, in order to note what improvement might be made in the strength of the castings as a consequence of the additions in question. Unquestionably the deoxidizing action was excellent, but whether any beneficial results other than greater machin-

ability and soundness can be obtained will remain for further investigation.

In making additions to a ladle full of molten iron, experience shows that about 0.1 per cent of the element to be experimented with should be sufficient to effect deoxidation, and usually none of the element can be traced in the casting unless at least that amount is used. If the percentage is increased the excess of the element in question above the quantity necessary for deoxidation will alloy with the iron itself and may or may not give additional beneficial properties to the metal. Hence in the tests made, the additions amounted to 0.05, 0.10 and 0.15 per cent cerium, lanthanum, etc. These figures are based upon an alloy containing 70 per cent of the rare metals in question.

Results of Tests

The first series of tests was with an all pig iron mixture, the analysis of the castings being silicon, 2.70; sulphur, 0.07; manganese, 0.60, and phosphorus, 0.64 per cent.

The results given are the average of four standard test bars of 1¼-inch diameter in each case.

	Transverse Strength Pounds	Deflection Inches
No Cerium, lanthanum, etc. added	2090	0.11
0.05 Cerium, lanthanum, etc. added	2450	0.12
0.10 Cerium, lanthanum, etc. added	2660	0.13
0.15 Cerium, lanthanum, etc. added	2840	0.13

The next series was from a 60 per cent pig and 40 per cent scrap mixture. It was good soft machinery iron, with an approximate analysis of silicon, 2.40; sulphur, 0.10; manganese, 0.55, and phosphorus, 0.68 per cent. The results given are the average of four standard test bars in each case.

	Transverse Strength Pounds	Deflection Inches
No Cerium, lanthanum, etc. added	2740	0.09
0.05 Cerium, lanthanum, etc. added	3110	0.10
0.10 Cerium, lanthanum, etc. added	3240	0.11
0.15 Cerium, lanthanum, etc. added	3280	0.13

The final series was made from remelted car wheels, giving close-grained iron castings. The analysis approximated: silicon, 0.55; sulphur, 0.13; manganese, 0.40, and phosphorus, 0.40

per cent. The results given are the average of four standard test bars in each case.

	Transverse Strength Pounds	Deflection Inches
No Cerium, lanthanum, etc. added	3790	0.11
0.05 Cerium, lanthanum, etc. added	4080	0.14
0.10 Cerium, lanthanum, etc. added	4190	0.15
0.15 Cerium, lanthanum, etc. added	Bars defective	

The standard 1¼-inch round test bars were cast into cores standing vertically with top pour. The cores were parked in a mold bedded in the floor, the bottom being caerfully prepared with crushed coke and a thin cover of molding sand. The sand between the cores was well vented, yet in spite of all precautions, the last set proved insufficiently so for the 0.15 cerium addition, and the bars were imperfect.

Effect of Artificial Cooling

Chill blocks were cast from each ladle so that a comparison might be made between normally set metal and when artificially cooled. The results were highly instructive, as the fractures indicated a prolongation of the setting period for metal treated with cerium, as against the untreated metal. Indeed, observation was made of a distinct heating up of the bars when passing the point of recalescence in cooling, besides the heating up of the molten metal in the ladles as the result of the alloy addition. This indicates that where important work is made and it is essential to feed up well, that cerium alloy be used or treated metal poured into the risers while pumping, so that the period of feeding may be kept up as long as possible.

It was noted that the chill tests of the gray iron sets showed relatively softer metal and fractures with smaller chilled rims for the treated material than for the original metal from the same ladles. The remelted car wheels gave exceedingly strong test bars, the treated ones considerably grayer than the untreated ones. The chill tests showed mottling for some of the treated metal whereas the untreated chills had absolutely white fractures with magnificent crystallization. The conclusion follows that in deoxidizing by means of cerium, as with any deoxidizer, the purified molten metal is given a better

chance to set under natural condition, being relieved from a too rapid freezing action with consequent formation of undue amounts of combined carbon. The metal, therefore becomes softer, is machined more easily, is freed from gas and pin holes, undue casting strains and has less internal shrinkage than where the metal suffers from more or less oxidation through imperfect melting practice.

Tests Verify Other Investigations

The above tests, made in the foundry of the writer, were undertaken to supplement a long series of daily tests at the Chicago Hardware Foundry Co., where a uniformly good increase in strength, machinability and soundness of castings was found as the result of cerium additions. The results at the two foundries are about the same. The interesting feature of the analyses made is that with additions of as much as half a per cent of cerium none could be found in the castings. Evidently the avidity of cerium for oxygen is so strong that after a portion has been used up in the molten metal, the balance must have been oxidized by continued contact with the air over the ladle. It is one of the noticeable features of the use of this alloy that much slag is taken from the molten metal, partly through increasing the fluidity and the balance from the oxidation products of the alloy itself. The metal cerium and its concomitant elements lanthanum, etc., seem to be particularly powerful deoxidizing agents, whereas other deoxidizers seems to have this property limited up to a certain point, any excess remaining in the casting.

Further work will be undertaken to get more light on the properties of this new ferroalloy and its effect on the various classes of cast iron. It is a well understood axiom in foundry work that the purer the metal as delivered from cupola or furnace, the better the chances for good castings. Hence anything that makes for purity, in addition to taking every precaution to get good stock, to melt it right and to gate the molds properly, is to be welcomed.

Discussion—Cerium in Cast Iron

The Chairman, Mr. W. A. Janssen.—Can cerium be present as a ferrocerium alloy?

Dr. Richard Moldenke.—Yes, it has to be, because cerium alone is so easily oxidized that it has to be carried with a large percentage of iron. This is then added to the ladle of molten metal. In adding all these ferroalloys to the ladle, it should be in powdered form and the best way is to sprinkle it on the stream of molten iron as it issues from the taphole of the cupola.

Mr. E. F. Cone.—I want to ask if Dr. Moldenke has given the composition of ferrocerium and if there are any other elements in it of importance, like titanium?

Dr. Richard Moldenke.—As far as I know, only pure iron is added to the misch metal, as they call it, and consequently the composition would be iron, cerium and several other metals of this group.

Considerations Affecting Brass Melting in the Gray Iron Shop

By R. R. Clarke, Seattle

Melting stands high among the particulars of brass practice. Representative experience will scarcely dissent from the opinion that inferior castings more frequently result from incorrect mixing and melting than from all other causes combined. Molders make their own scrap; furnaces can make everybody's.

All reputable brass foundries appreciate the significance of melting and equip along the lines and policies dictated by experience. The iron shop making brass occasionally is not so favorably situated. Lack of time, knowledge or inclination sponsors neglect of the importance of melting and often forces the inevitable consequence in the castings. Discussing the question from the iron viewpoint, we can scarcely realize that exhaustion of detail so absolute to exclusive brass experience. We shall, however, aim to cover the general features, hoping that those interested may be able of themselves to fill in the more important particulars.

From a melting standpoint, nonferrous is by no means ferrous; neither is an alloy of either a combination of the other, nor is any alloy of any constituency identical with any alloy of any other composition or to any one metal element entering into the composition. Every metal element has its melting peculiarities in both single and combined state and these broad facts of difference are fundamentally requisite to results. With them iron men must strive to do as brass men do, recognize and reckon with these differences.

The subject may best be discussed under its separate heads. First let us consider metal selection and mixing practice. Common practice among iron men leans toward loose brass scrap of unknown composition and indefinite antecedents. This tendency is a bad one in that all the constituents in the different nonferrous alloys are not congenial to each other when thrown together in a conglomerated mass. Thus a quantity of loose scrap containing some yellow brass, some red, some Tobin

bronze, manganese bronze, Muntz metal, some phosphor bronze and some aluminum bronze for instance—and in indiscriminate scrap it is easy to find all these types of alloy—would make a bad metal to handle besides yielding physical properties in the casting entirely unfit for any practical purpose in general. Experienced brass men can fairly well judge brass scrap by color, fracture, etc., though the best brass foundries go farther than that through analysis in their laboratories. To the average iron foundry these advantages are denied so the better policy is to purchase and use selected scrap approximating known composition. It would perhaps be better still to purchase scrap brass ingot under analysis; this comes but slightly higher than loose scrap. In so purchasing, it is well to patronize reputable sources, since not all the firms making scrap ingot turn out a high grade product. Scrap ingot usually may be divided between that containing zinc or that high in zinc and that including no zinc or low in zinc.

Zinc is highly determinative of certain alloy qualities. It controls color, density, toughness, malleability and cleanliness but loses out in hardness and in antifrictional qualities. Thus we want zinc in golden color metals, in most pressure metals and in the softer, tougher metals. But we cannot have much of it in the harder metals or in the bearing metals. On tin and lead we must rely for these respective requisites.

If the iron foundries doing occasional brass work would keep two kinds of ingots on hand, the one inclusive and the other exclusive of zinc, and at the same time carry a limited stock of virgin copper, tin, lead and zinc they could approximate at reasonable cost a high grade alloy of most any desired constituency. They could do this by adding one or more new metals at the expense of others in the ingot as the case might require. Out of an ingot approximating copper 80, tin 10 and lead 10, which is an excellent bearing metal, they could by adding 90 pounds of copper and 10 pounds of zinc to 100 pounds of the ingot realize a high grade red brass applicable to the average purpose. This metal would approximate very closely the formula copper 85, tin 5, lead 5 and zinc 5, which is quite common and reputable in brass foundry work.

When loose and indiscriminate scrap must be resorted to, some effort at least should be made to pick it over and get the best for the more particular cases. The better grades of brass will usually be found in such castings as valve bodies, stems, disks, bonnets, glands, plugs or keys; and also in the better class of plumbing goods, in locomotive steam castings, and in most cases where the casting is known to have rendered some particular red brass service.

In making up alloys from new metals altogether, the order of adding the metals is important. The general and safe rule is to melt the copper to a fair liquid state, add the tin and lead and finally the zinc, stirring the bath well during the entire process of adding all metals. The zinc should be added in small rather than large pieces and thoroughly stirred into the bath. Though somewhat foreign to the subject, a passing glance at the more common metals used in brass alloys and their effects on each other might be worth while. These metals are copper, tin, lead and zinc. An idea of the function of each will appear in the following table:

		Color	Prevailing property	Oxidizing tendency	Fracture	Common Alloy	Uses
COPPER	+ tin =	pale	hardness	strong	fine	cop. 80, tin 20 cop. 83⅓, tin 16⅔	Bells
	+ lead =	grayish	plastic	strong	medium coarse	cop. 70, lead 30 cop. 50, lead 50	Bearings and steam packing
	+ zinc =	yellow	soft and tough	overcome by zinc	fine	cop. 70, zinc 30 cop. 66⅔, zinc 33⅓	Tubing, sheeting, ornamental and rolling mill work
	+ tin + lead =	pale	medium hard and strong	strong	medium fine	cop. 80, tin 10, lead 10 cop. 78, tin 7, lead 15 cop. 80, tin 8, lead 12	Bearings
	+ tin + lead + zinc =	reddish	medium hard strong and tough	controlled by zinc	somewhat crystalline	cop. 85, tin 5, lead 5, zinc 5 cop. 86, tin 3½, lead 3½, zinc 7	Steam pressure metals
	+ tin + zinc =	reddish	hard, strong, tough	strong and proportionate to zinc	crystalline	cop. 88, tin 10, zinc 2 cop. 87, tin 8, zinc 5	Bushings, large valves, gear wheels
	+ phosphorus =	pale	hard brittle	completely dominated by phosphorus	fine	cop. 90, phosphorus 10 cop. 85, phosphorus 15	These alloys are never used except as concentrates to facilitate introducing phosphorus into the different alloys

Contamination is a great evil in a brass alloy and of these contaminating metals none is more detrimental than iron. The eternal vigilance of the brass foundry man is required to keep iron strictly out of his alloys. From this simple fact iron foundries can learn a valuable lesson in the use for brass purposes of furnaces, ladles, gates, stirring rods, etc.

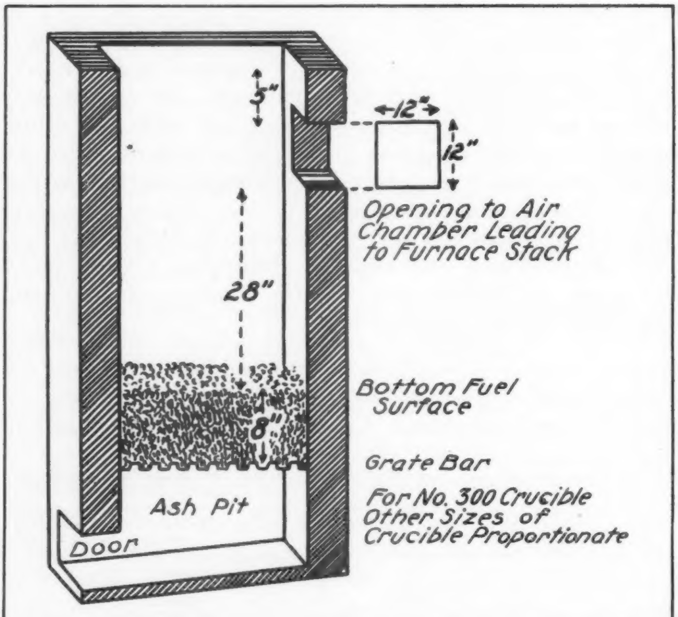

FIG. 1—A DESIGN FOR A SIMPLE CRUCIBLE-TYPE NONFERROUS MELTING FURNACE

The second consideration is the melting medium. For brass melting we have as a possibility the use of crucibles in a pit furnace with either natural or forced draft. The air and oil furnace, the gas-fired furnace, the electric furnace and in some cases the cupola, also are employed. Pit melting with proper equipment is very efficient but at the same time expensive, due to the crucible item. It takes more than a mere hole

in the ground lined up with fire brick and connected with a stack to make a good pit furnace. Certain dimensions and relations must be observed as shown in Fig. 1, which is taken from a very satisfactory furnace used by the author for years. Good practice in pit melting consists in a substantial bottom bed of coke, in keeping the crucible in a centrally standing up position, in being careful to keep the coke from covering or falling into the melting or molten metal and in protecting at all times the surface of this metal from the oxidizing influence of the atmosphere and from the gases of combustion. One of the best known and efficient protectives against these is common charcoal pounded up into small pieces and placed in goodly quantity over the metal surface. Another common practice is to use pulverized glass which fuses and forms an almost seamless covering.

Pit melting expense can be greatly reduced by proper care of crucibles. In this connection the following will be found valuable:

1.—Crucibles should be kept in a warm, dry storage room.

2.—When not in use for any length of time they should be returned to this storage room.

3.—They should always be properly annealed before entering the furnaces.

4.—Proper annealing consists in a very slow raising of the temperature to at least 150 degrees Cent. The applied temperature should likewise be uniformly distributed.

5.—They should be given careful protection in poking the fire.

6.—Pigs or chunks of solid metal should never be placed in wedging form into crucibles.

7.—Heels of metal should not be permitted to freeze up in them.

8.—Tongs should be made and kept in such condition as to lift the crucible without squeezing it unduly or at any one point.

9.—Using the top edge of a crucible as a lever fulcrum by which to lower heavy pieces of metal or throwing chunks of metal into crucibles carelessly is destructive practice.

10.—Direct contact of flame on a crucible not annealed or on one in process of annealing is superlatively injurious.

11.—When melting by air and oil, an end to be striven for is to avoid striking the crucible with the air and oil jet or flame. Such practice scores the crucible away rapidly.

Pit melting by gas instead of coke is quite practicable though dependent largely on facility and cost of fuel supply. Insofar as metal results are concerned there seems to be little if any difference.

Air and oil melting is the decided tendency of the day. Properly executed it is an efficient and convenient method, comparatively inexpensive. There is much about it, however, to engage judgment and common sense. Primarily essential is proper and dependable auxiliary equipment. This lies at the very foundation of successful manipulation. Good air supply is represented by ample volume but not too great pressure.

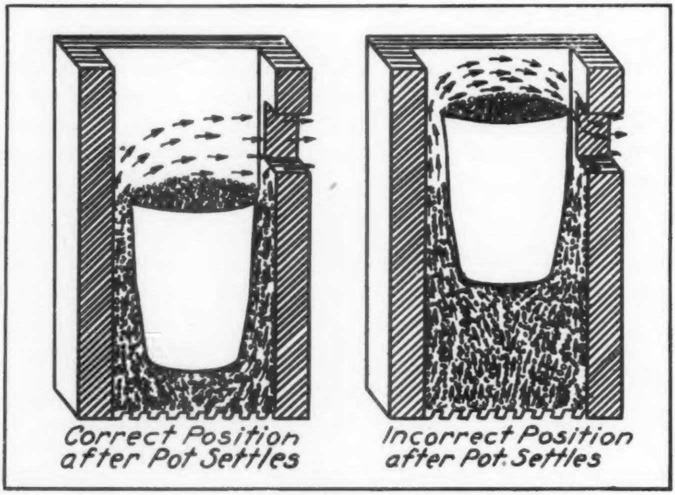

FIG. 2—EFFECT OF IMPROPER FIRING IN A CRUCIBLE MELTING FURNACE

The proper flame, and consequently the correct proportions, of air to oil are best judged by color. A flame too white or clear or one tinged with green is oxidizing and decidedly detrimental. Personally, we prefer a soft flame, clear and all but smokeless yet not absolutely void of a remote yellow suggestiveness. The temptation to conserve oil is always

strong but it is well to remember that oil is cheaper than metal when the conserving desire becomes unwisely active.

Selection of the Furnace

The different makes of air and oil furnaces are many, and for the most part reputable. In stating a preference we base our opinion entirely on the results we have obtained from the object of our partiality. Nor do we presume to intimate that, given the same careful study and attention for the same time, other makes of furnace would not have yielded results equally satisfactory. We prefer the Schwartz furnace because in our present position we inherited it, studied it and realized the very best results from it. With a Rockwell or a Monarch, for instance, we have little doubt but that we could have made a similar showing, as others have done with them. In every detail we have found the Schwartz eminently satisfactory and have melted all kinds of alloys, of scrap and different metal elements with a very low percentage of impaired metal. For a long time now we have melted exclusively in Schwartz furnaces and cannot see that any other types of furnaces or methods of melting could have given any better results. They must, however, be given careful attention in which the following points are chiefly important:

Furnace Operation

1.—Keep them scrupulously clean. Slag out and clean well after every heat.

2.—See that no sutures or bare spots are allowed to exist in the lining.

3.—Do not permit undue accumulation of slag on the molten metal.

4.—Watch the flame closely seeking to realize a good reducing flame not too violent.

5.—Use a good grade of oil.

6.—Do not allow the air to be on while the oil is off.

7.—In melting large heats change the position of the furnace frequently by rocking it.

8.—Never expose the metal to the flame a moment after the proper metal temperature has been reached. Soaking metal is one of the primary evils of melting.

9.—Melt and dispose of the metal as quickly as possible.

10.—Strive as far as practicable to keep charcoal on the metal surface, especially during the period from its first molten state up to its pouring temperature.

11.—After the metal has been reduced to a fairly liquid state, open the furnace, skim off the accumulated slag and dross, throw on a good sized shovelful of coarse charcoal, and then restart for heating up to proper temperature. Other than this no interruption should occur in the melting process.

12.—When transferring metal from the furnace to the mold, ladles should be clean, well preheated and the metal surface always should be covered with a fresh layer of pounded charcoal.

The Electric Furnace

Involving the essentials and meeting the conditions of orthodox doctrine in brass melting, the electric furnace represents the ideal possibility. Though now beyond its experimental stage and making long strides toward a stable basis, so far as we have been able to learn, it has yet to attain its perfected practical state. When it does reach that point in dependability, in facility, in cost of upkeep and of melting, etc., all other methods, we believe, will become secondary considerations.

Cupola melting has never been favorably considered by brass men. It is nevertheless possible and in some cases practical. We have personally found it so in melting down foundry sweepings, screenings, etc., and we know high grade manganese bronze to have been made in the cupola. In making this metal the copper only was melted by cupola and the zinc stirred into the hot copper bath after the latter was drawn out into the ladle. It is scarcely necessary to add that only large heats were thus melted.

Metal Temperatures and Protection

Next we strike the question of metal temperatures and metal protection, the latter including the important question of fluxes and reagents. All these can be best considered jointly. The two great evils attending brass melting are oxidation and gas absorption. The former will be best understood from the statement of the fact that practically all known metals at certain temperatures combine rapidly with oxygen,

producing either an oxidized metal or a complete metal oxide. To oxidize really means "to combine with oxygen" and is in many respects synonymous with the common expression "to burn."

The difference between "oxidized metal" and metal oxide we observe as that between a metal only partially oxidized and one completely oxidized. In the one case we have as it were a "scorched" metal, in the other a metal completely burned to dross or ashes. Oxidation is a consequence chiefly of contact with the atmosphere which is a mechanical mixture of oxygen and nitrogen. Oxidation increases with temperature, with exposure and with time. To minimize oxidation in melting then means to get the metal no hotter than necessary, keep its surface well protected from the atmosphere and get it out of the furnace and poured on short order as soon as it is ready. Oxidation causes weak, drossy and spongy metal, wholly unfit for any general purpose. Many castings are lost and many others fail in service by it.

What Gas Absorption is

Gas absorption consists in the taking up of gases by molten metal at high temperatures and releasing them in the process of solidification. The active and expelling stage of these gases is strong in the plastic state of the metal and results in a most distressing honey-combed and porous effect in the casting. Though given considerable study by both practical and technical men, the nature and origin of these gases have not been definitely determined or at least agreed upon. That they are allied more or less intimately with oxides and oxidation seems fairly certain since they arise from similar conditions and respond to like cures, in part at least. A fairly complete discussion of their nature, cause, prevention and remedy will be found on page 121 of the March, 1919, issue of *The Foundry* and those interested may find this discussion of value. It is only necessary here to remark that this condition is usually characterized by a swelling up of the gate head in cooling and follows such evils as poor grades and bad combinations of metals, dirty and slag-polluted furnaces, damp furnace and ladle linings, poor

grades of fuel, soaking the metal, and extremely high pouring temperatures.

The rule is fairly general, though not infallible, that a correct pouring temperature will not seriously admit the evil even though the metal at that temperature represent a reduction from a higher one.Oxidation is the brass man's inevitable curse. He cannot escape the atmosphere nor the chemical reactions it induces. True there is much he can prevent, but despite the greatest caution much will ever develop and remain to be cured. The cure lies in the fluxes which are of two kinds, neutral and active, representing respectively those that do not become a corporate part of the metal nor alter its inherent properties and those that do. Of the neutrals, the most common are charcoal, plaster of paris, and common salt used principally as surface coverings. Personally we use nothing but charcoal and find that it proves amply sufficient.

Function of Charcoal

A word explaining its function is worth while. Charcoal is carbon and at its "kindling" temperature has a great affinity for oxygen. Oxides floating on the surface of the metal are combinations of oxygen and metal. The function and power of charcoal is to take up the oxygen of the oxide and leave the metal clean and clear. This it does admirably, besides forming a protective covering to exclude the atmosphere. Charcoal's greatest value is in the burning which represents the chemical reaction or oxidizing process. Obviously then the top of the metal in the ladle should be well covered during pouring, with charcoal in burning state. Once burned to ashes its function practically ceases. Our charcoal bill is always high but our castings are for most part sound.

Active fluxes are sometimes referred to as reagents and deoxidizers. Always they are highly oxygenating substances. Most common among them are zinc, phosphorus, silicon, magnesium and manganese. But three of these will require comment here, they being the most widely used and covering general requirements. If we melt pure copper and pour it into molds, chances greatly favor its rising and flowing back

through the pouring gate, resulting in a porous and oxidized condition in the casting. If to this pure copper, we add 3 per cent of zinc, or ½ of 1 per cent of phosphorus, or a small amount of silicon the evils will at once be corrected. In the copper tin-lead alloys, zinc or phosphorus only are used, silicon being accorded no standing. Zinc is seldom used for deoxidizing purposes exclusively while phosphorus usually is. The reason is that in a great many alloys zinc is used for the quality it supplies and because its presence obviates the need of any further reagent. With phosphorus, this is not the case. It is used purely as a deoxidizer in those alloys from which zinc and its qualities are barred. Zinc quality is wanted in pressure-resisting metals, so it forms an equal part with tin and lead in the 85 copper alloy. It is not wanted in a bearing metal, so the 80-10-10 copper, tin, lead alloy is fixed up with from 0.5 to 1 per cent of phosporus. The use of both zinc and phosphorus in the same alloy is considered bad practice, especially high percentages of either. Used purely as a deoxidizer from 2 to 5 per cent of zinc and from 0.25 to 1 per cent of phosphorus will suffice for the average purpose.

Zinc and Phosphorus Burn Out

With high temperatures and repeated remelting, both zinc and phosphorus burn out of the alloy. In melting all scrap it is therefore good practice to add small quantities, from 1 to 2 per cent of zinc and 0.1 to 0.25 per cent phosphorus, to reciprocate that lost and control the oxides. In the case of zinc this is invariably our practice. Phosphorus is added to the alloy in the form of a concentrate which itself is an alloy of either phosphorus and copper or phosphorus and tin and known respectively as phosphor-copper and phosphor-tin. The use of either presupposes wideawake figuring. Phosphor-copper is usually copper 85 per cent and phosphorus 15 per cent. To get 1 per cent of phosphorus consequently means the use of 6 2/3 pounds of phosphor-copper; and to make a 100-pound mix reading copper 79, tin 10, lead 10, phosphorus 1 requires copper 73 1/3, tin 10, lead 10, phosphor-copper 6 2/3 pounds.

Relying on phosphorus as a cure-all for loose melting practice is bad policy and it should be resorted to at times and

in quantity only as unavoidable conditions require. Silicon is used almost exclusively with pure copper to reduce its gases and oxides. In practice we have never reduced its quantity to a percentage basis relying instead on judgment as influenced by varying conditions of melting and prompted by the appearance of the molten copper mass. The use of manganese and magnesium is not widespread. Charcoal is not a logical flux for aluminum which does better under chloride of zinc.

The Question of Pouring Temperature

On the pouring temperature depends largely the cleanliness and solidity of brass castings. No wide margin lies between a proper temperature and one too low or too high. Generally it is better to pour hot than cold, though the consequences of either extreme are equally distressing. From cold metal come bad shrinking, drawing, drossy and spongy metal and improper metal unions between different casting sections. From metal too hot arises the porous and honeycombed effect caused by the dreaded gases.

To discuss pouring temperature at length is not within the province of this paper. In passing we pause to point out an important particular, namely that there is a heavy loss of temperature between the furnace and the mold with the mold the determinate point and that the more this loss can be reduced by well preheated and clean ladles, by rapid disposition of metal, etc., the better the results will be. It is a fundamental principle of good brass melting practice to get the metal no hotter than necessary and hold it no longer than absolutely required.

Summing up this paper we note the following:

1.—Good metal is essential to good castings.

2.—Unknown scrap indiscriminately used can never be trusted to produce a clean, solid casting.

3.—Percentages of new metal along with scrap greatly improve quality.

4.—Whatever the melting method, dependable equipment and right ways of doing things are indispensable requisites.

5.—Iron must be kept strictly out of brass.

6.—Brass can be melted by pit-crucible furnace, air and oil furnace, electric furnace and by cupola. Present day practice is largely air and oil.

7.—Cleanliness of furnaces, ladles, etc., makes for metal quality.

8.—Slag is distinctly detrimental.

9.—Rapid melting and quick disposition of metal favors results.

10.—A reducing flame is a melting flame with a minimum of oxidation and represents correct proportions of air and oil at proper pressure. Its color is white, remotely yellow.

11.—An oxidizing flame melts and oxidizes seriously. Its color is extremely pale intermingled with green and the flame is very thin.

12.—Good fuel is a melting asset.

13.—Holding (soaking) metal in the furnace following its readiness is among the worst of evils.

14.—Absorption of gases originates chiefly in high metal temperatures in the furnace and at pouring. Pouring temperature is therefore an important item.

15.—Oxidation derives mainly from atmospheric contact and increases with time, temperature and surface exposed. Its prevention lies in the protection given the metal surface and in the neutral fluxes. Its cure lies in the active fluxes or deoxidizers.

16.—Charcoal has an indispensable value in preventing and reducing surface oxides. It should be generously resorted to as a covering.

17.—Phosphorus, zinc and silicon are the more common deoxidizers. With pure copper any one can be used when not otherwise barred. Phosphorus and zinc are used chiefly for the alloys, the former occurring principally in those to which the latter is not included. In most any alloy not too high in zinc, copper 88, tin 10 and zinc 2, for instance, a mere trace of phosphorus makes for cleanliness and solidity of the casting.

18.—Lead and copper mix very imperfectly. Alloys containing more than 10 per cent lead should therefore be stirred vigorously in pouring to insure a uniform mixture.

19.—To slag out furnaces use lime, fluorspar, soft coal, oyster shells or common charcoal.

20.—Alloys containing phosphorus sand-burn the casting severely if poured too hot.

21.—Furnaces slag out well with lime, fluorspar, soft coal, charcoal or oyster shells.

22.—Prevention in melting is better than cure.

Weeks' Electric Rotating Furnace as Applied to the Brass Foundry Industry

By F. J. Ryan, Philadelphia

Philadelphia in 1908 saw the birth of the rocking electric furnace idea applied to the problem of brass, zinc and non-ferrous alloys. To Charles A. Weeks, a Philadelphian, must go much of the credit for both the conception and the solution of the problem because of his untiring efforts in the face of unusual obstacles.

To see how clearly Mr. Weeks seemed to have sensed a solution of the electric brass furnace problem, we have only to inspect the equipment shown in Fig. 1 which might readily be mistaken for a photograph of a modern installation, whereas it was taken nearly 10 years ago at the works of the General Electric Co. where Mr. Weeks carried out many tests in co-operation with the designing engineers of the same organization. Some of the zinc ingots produced can be seen on the platform at the side of the furnace. Comparison of the original furnace with the present design as shown in Fig. 2 shows only a general refinement and solution of operating, and mechanical problems without radical changes in the basic thought.

Two Vital Problems

Brass melting presents two vital problems: Segregation and volatilization of zinc.

Segregation results from the different fusion or melting temperatures of the different alloys. In other words if you have three alloys, each with a different melting or mixing point, you will find that at the time when the material with the lowest melting point has become liquid, the other two are still sluggish and will not combine unless some method of stirring is

resorted to. On this account in a still bath hand stirring or rabbling must be resorted to, or else sufficient heat to bring all the constituents to the combining temperature must be applied. In such cases, however, the zinc has reached a point where it becomes volatile and a large part passes off as gas.

A solution for this condition in an electric furnace is automatic stirring whereby the surface exposed to the arc is

FIG. 1—WEEKS' ELECTRIC ROTATING BRASS FURNACE OF AN EARLY TYPE

continually changed. The revolving furnace is designed to accomplish this result.

It has always been recognized that a great advantage would be gained if the heat could be applied at both the top and bottom of the charge. Mr. Weeks seems to have secured this result in his first experimental furnace. He secured both the

result mentioned and obtained a mechanical means of stirring the bath.

How Bottom Heat is Secured

The application of bottom heat is obtained through the absorption value of the refractory lining; that is, the lining section exposed directly to the electric arc absorbs a large amount of heat and when this in turn becomes the hearth as the furnace rotates, it gives out the absorbed heat to the charge from the bottom. With the steady alternation of the hearth against the charge there is a continual application of heat. While this alternation is going on, the charge is stirred by the movement of the furnace body. Further, by the alternation of the exposed refractories, the wear from burning or fusing from the high heat of the arc is reduced to a minimum.

Briefly, without going into technical results which cover a wide field and would take a large amount of space, it can be seen from practical observation that through the simple discovery of Mr. Weeks, important problems in the field of brass foundry melting have been solved, at least until such a time as our ever changing mechanical and chemical applications bring to us some new discovery.

In the following paragraphs will be reviewed briefly the principal details in connection with the construction and method of operating this equipment.

Furnace Lining

All available refractory materials applicable to this type of furnace equipment have been experimented with and while fair success resulted from the use of 9-inch clay blocks with a 6-inch layer of electrically fused magnesite mixed with china clay and boric acid, it was finally decided to recommend for the present a special silica lining.

The blocks composing this lining are reduced to a minimum with a proper allowance for shrinkage. Actually, the circular section is composed of six interlocking blocks capped at each end with a solid capping piece. Between the shell and the lining is placed 2 inches of insulating material in a loose form

which allows for the expansion of the main lining and reduces radiation to a minimum.

By constructing the lining in this manner, quick replacement is made possible and a large percentage of the checking wear eliminated as would be the case in a lining composed of small brick.

From the reports received from a large manufacturing concern in this country, the writer has every hope that

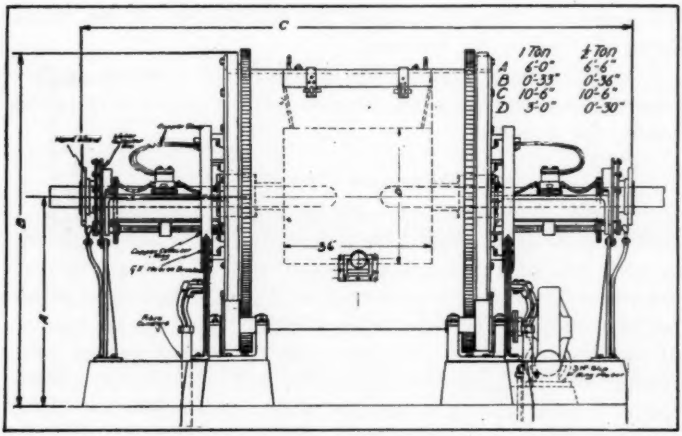

FIG. 2—IMPROVED DESIGN OF ROTATING ELECTRIC BRASS FURNACE

within a short space of time it will also be possible to supply a lining of magnesite blocks made under a special process in the same form as the present lining. Experiments so far carried out show promising results. The furnace of course, can be lined with any other materials chosen by the operator.

Electrodes

Graphite electrodes are recommended on account of their current carrying capacity and lightness which allows for ease of handling and cuts down loss in breakage. The furnace however, can be adapted to the use of carbon electrodes where desired.

One of the chief radical changes from the original furnace design is the method of taking power into the furnace. In previous designs it has been necessary to have objectionable overhead swinging cables to allow for the movement of the furnace drum. Such construction causes loss in voltage on account of excessive length of cable and necessitates a very much greater amount of room for installation than is necessary under the design submitted, whereby the current is taken in through a shoe at the bottom of the furnace out of the way of the operator. This also allows for the placing of the transformers close to the furnace.

In this type of construction it also is not necessary to disconnect the cables when the furnace body is removed from the rollers for relining.

Mechanical Operation

Briefly the furnace, as will be noted from Fig. 2, is a circular steel drum located on four rollers with double gearing at each end of the drum connected with a driving shaft at the rear. The shaft is connected to a gear reduction to allow for two complete revolutions per minute. By a special method of automatic switches the drum can be rotated to any percentage of its circumference at the will of the operator, a special control making it possible to set operation at any given point.

Water connections are made through permanent entrance from below to a sliding water jacket which allows for a larger flow or cooling capacity at a low pressure, and also eliminates flexible and overhead piping.

The electrodes, it will be noted, are driven by a wheel stationed at the axis of the furnace, making no movement on the part of the operator necessary except a gripping of the wheel, and allowing the motion of the furnace body to take care of the necessary movement.

Both the electrode clamp and the electrode socket at the entrance of the furnace are water cooled at both sides of the furnace.

On account of the method of lining and the general simple construction of the furnace it is possible to put in a

door of practically any size necessary to meet operating conditions. The pouring spout is located at a point whereby it is possible to entirely empty the full charge of the furnace with a spout movement of only 2¾ inches. If necessary as in ingot pouring for the rolling of copper or brass sheets, a connection can be made to the rear driving shaft whereby the

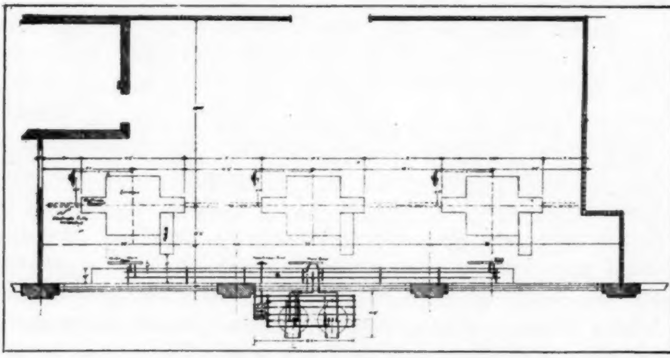

FIG. 3—A TYPICAL THREE FURNACE PLANT

ingot carriage will be synchronized with the movement of the furnace spout.

Fig. 3 shows a typical layout of three 1-ton furnaces. It is included to show the possibilities of installation of this type of furnace. When it is realized that each one of these furnaces would have a capacity of 20 heats per day of 24 hours, giving a total daily capacity of 60 tons within approximately a floor space of 60 x 60 feet, it will then be appreciated what this development has made possible in the way of increasing plant capacity without the necessity of additional floor space.

Theoretical Advantages

It may be well to mention briefly the theoretical advantage that the electric furnace has over the ordinary oil-fired furnace. Operations and experiments have proved that such is the case, but the theory is also interesting in that it shows that we have not yet reached the ultimate possibilities which

will come when the art has been finally developed to its highest point of efficiency.

The electric furnace may be made practically a sealed instrument preventing the access of air which means that so long as the vapor pressure of zinc in the charge does not exceed atmospheric pressure, the maximum possible loss of zinc must be the furnace fuel of zinc vapor.

At the usual pouring temperature of a 20 per cent zinc brass each cubic foot of gas saturated with zinc vapor contains approximately 0.025 pound of zinc. In a perfectly closed electric furnace of 150 .cubic feet capacity (one of Weeks' experimental furnaces) heated uniformly, the maximum loss due to volatilization would be 3.75 pounds zinc; and this would be practically independent of the total amount of brass in the furnace, and also independent of the length of time the metal was kept at that temperature. With a 2-ton charge the loss would be 0.094 per cent. Similarly the loss of zinc from a 40 per cent zinc brass at its usual pouring temperature would be somewhere near 0.12 per cent. The loss of copper would be negligible so far as volatilization is concerned.

On the other hand, we have seen that the fuel-oil fired furnace requires that some 10,000 cubic feet of hot combustion products leave the furnace for each 100 pounds of red brass melted. If these gases left the furnace saturated with zinc at the final pouring temperature, they would carry with them many times the amount of zinc originally charged. Fortunately the gases do not by any means all leave the furnace saturated with zinc at the final pouring temperature, not even the gases towards the end of the heat, since with a uniform gas velocity the gas does not remain in the furnace for more than a fraction of a second. But if brass in left is an oil-fired furnace, under blast, after it is ready to come out, it does certainly follow that the zinc percentage in the melt will drop off at an alarming rate.

The same arguments might be used in comparing opportunities for oxidation. Considering both practices in practical operation, it is quite certain that the electric furnace has the decided advantage.

It can therefore be seen that the possibilities of a furnace of the design submitted operating on brass has tremendous possibilities in connection with the saving of zinc that is now being lost through volatilization.

Results already accomplished on material such as electrolytic copper show a loss not exceeding 0.75 per cent and in high zinc mixtures the losses run anywhere from 1½ to 3½ per cent varying with the zinc contents.

Theoretically and practically there is no loss in copper, but in actual practice small amounts become impregnated with the lining or pass off in the slag.

In closing the writer would like to explain the apparent lack of submission of technical data supporting the claims made herein. This is intentional for the reason that the usual brass foundry problem is individual and not collective. For instance, the average brass foundry in the Detroit district catering to the automobile trade may be using mixtures which would be quite different from those that would be used in the Philadelphia foundry catering to the shipping industry, and as the user will want to know the operating conditions surrounding his own problem, it was decided to make the paper general.

It might also be mentioned that guarantees of operation are many times confusing. By this statement it is not meant to intimate that engineers or manufacturers misrepresent their product, but to point out that they are highly specialized in the handling of their own individual product, whereas the installation must be adapted to a human organization and into problems of general metallurgy enters more human intelligence and co-operative ability than probably in any other. Although a special trained corps of experts may be able to produce specific results, this is no guarantee that the ultimate customer will obtain these same results unless the organization is always available for co-operative work.

In other words, the engineer or engineering contractor should take a new place in general industrial operations. The mere design and installation of equipment should not sever his relations. The practical man recognizes the necessity of the expert to his organization and the expert should recognize and promote closer relations with the practical man.

The Care of Foundry Equipment

By G. L. Grimes, Detroit

Many foundrymen own automobiles. What is their attitude toward properly caring for them? It will be admitted that most of them, if they oil their cars themselves, attend to the parts most accessible. They place oil in the crank case of the motor and screw up the grease cups on the springs because these parts are conveniently near at hand. Many of us have had the speedometer stop working and have been told at the repair station that the lower end had not been lubricated.

Although the motor car has to contend with the dust of the road, it operates under far better conditions than obtain in the average foundry where dirt and grit attack the bearings of equipment. Most men make it their business personally to see that their automobiles are oiled, but how many give as much thought to the care of their foundry equipment?

Machines to Offset Labor Shortage

It is generally expected that there will be a large exodus of foreign labor and probably comparatively little immigration. The second generation of foreign labor does not care to go into the foundry but prefers the machine shop. With the decrease of labor and the increased demand for better output, combined with the growth of the idea of the conservation of material and resources, the foundryman faces new conditions and must develop new methods and processes by which he can elevate the plane of his profession and make up for the shortage of men by the installation of more machinery. The addition of machinery brings with it the problem of maintenance.

In the future will manufacturers consider the foundry a necessary evil while they take great pride in the machine shop? The writer hopes not. Manufacturers realize that they have made an investment for capital account when

they buy a lathe or milling machine for the machine shop. They install it in a clean, well lighted shop. Each operator is required to keep his own machine clean and many shops allow special time for this purpose. Machinists are trained to oil their own machines, and a man is made responsible for oiling the lineshafts and motors. A tool room, with the best mechanics in the shop, is usually provided to repair the equipment when it breaks down.

Many of the automobile machine shops have extra machines so that in an emergency a new machine can be substituted quickly and production continued. The machine that is taken out is turned over to the tool repair department and properly repaired.

Foundry Machinery Often is Neglected

But this policy does not seem to hold true in regard to foundry machinery. In many cases, the machinery is purchased, and no more attention is paid to it as long as it runs. The foundry process is a dirty one. The sand and dust that flies when the molds are being shaken out covers everything in the foundry, and many foundrymen act as if it is useless to attempt to keep machinery clean. When installing equipment, many neglect to provide a proper place for it. Think of installing a motor driven air compressor in the dust of the cleaning room! But it is done.

Some foundrymen allow the night gang to shovel the sand back, covering the molding machines so that the operators have to dig them out every morning. This delays production and damages the machines.

Did Not Want to Pay for Own Carelessness

A steel foundryman called the manufacturer of his sand mixer and claimed it would not work properly. The equipment manufacturer found that the main bearing had not been oiled and the brass was nearly worn out, yet the foundryman wanted it replaced free of charge.

If an automobile begins pounding and the garage man has to put in new rods or bearings, the owner does not expect him to replace the parts and throw in the labor.

because the machine was purchased from him. Moreover, does the foundryman replace free of charge castings that are defective through no fault of the foundry? In other words, are machine scrap castings replaced free of charge? Of course not.

Manufacturers with machine shops frequently install highly specialized automatic machines to save seconds when finishing large quantities of pieces. There is an automatic molding machine that is faster than any other machine on the market, yet few foundrymen will use it because they will not give the machine and the equipment the care that the machine shop would give an automatic as a matter of course.

Equipment Changed with Superintendent

The change in foundry methods caused by the introduction of machinery is calling for mechanical training that was not necessary with the old floor methods. Too many foundrymen depend on their hunches that the equipment is all right or not. Often when foundry superintendents and foremen are changed, the entire equipment is changed. This is an economic waste which reacts seriously on the industry. Equipment is often condemned when it only needs a little intelligent care.

One example is typical. During a call at a foundry, a well known power rock over molding machine was condemned because it would not rock over. The handle for the 3-way operating valve had come off and had been replaced improperly so that the valve seemed to be leaking all the time through the exhaust opening on the valve. Somebody had screwed a pipe plug in the exhaust opening and there was no way to let the air out of the cylinder to complete the rockover. It was repaired in five minutes, but the machine had been discarded for months because there was no upkeep man with sufficient intelligence in the foundry to fix it. The average foundry depends on the handy man flask carpenter to oil and repair the machinery. It is absurd to think that the flask carpenter can take care of the electric crane, air compressor, sand cutter and molding

machines. In the first place he does not have time, and in the second place he seldom has had the proper training.

Idle Machinery Should be Protected

Many foundries buy equipment for certain work and when that is completed, the equipment is taken out into the back yard and allowed to rust. When it is needed again it is found to be ruined. A little care in covering it up and slushing with grease would save thousands of dollars every year.

Others, when their molding machines are out of service, allow bottom boards, old shoes, shirts and all sorts of trash and dirt to accumulate on them. When a job comes that could be run on the machine, it is too much bother to dig it out.

The logical and cheapest way to reduce the foundryman's worry is to hire a competent master mechanic or upkeep man to look after the mechanical details of the equipment in the foundry, as is done in rolling mills, machine shops, paper mills, etc.

The combination of foundry sand, dust and oil is real dirt. The man who works in it and who takes care of the machinery properly is entitled to a fair wage. The man who knows the condition of all equipment and can head off trouble in the foundry is a valuable asset to a foundry.

With the installation of sand handling machinery, conveyors, etc., where the breakdown of one conveyor shuts down the whole foundry, managers are beginning to realize that upkeep is as important in the foundry as in the machine shop. However, the large majority of foundries have not yet reached this point.

Overruled Mechanic; Plant was Shut Down

A man who has given his whole thought and training to this class of work can tell how and when to look for trouble. For example, a master mechanic of a foundry equipped with conveyors, and other mechanical equipment, asked to have the foundry shut down on a Saturday, about the fifteenth of May, as he did not think the conveyor

would run longer without certain repairs. The production manager decided that the plant could not shut down then, but agreed that the work could be done during the Decoration day lay off. The conveyors broke down on the Wednesday following May 15, causing a loss of production of two days instead of the half day, as suggested by the master mechanic. Needless to say, after this experience when this master mechanic thinks repairs should be made, they are made.

Fully 95 per cent of the trouble with foundry equipment is due to improper lubrication. Where it is possible heavy grease should be used on revolving shafts as it will form a collar of grease outside the bearing, making the finest dust protector possible. On some sliding surfaces on handrammed molding machines, ordinary plumbago or facing makes an excellent lubricant as the sand does not stick to it. One superintendent experimented with different oils on his molding machines and found that the fuel oil used in melting furnaces washed the sand out of the sliding surfaces and had enough body to properly lubricate the surfaces.

Uses Novel Method to Insure Oiling

The complaint is heard that the men do not seem to take the interest in their work they formerly did. In order to have some check on the man in care of machines, one foundry has installed a watchman patrol system with a key at every important bearing, machine and motor. The oiler carries the clock, which he must ring at every station. By this clock record, the superintendent at least knows that the oiler has visited each place.

When a molding machine is out of service in this plant, it is cleaned up and boxed to protect it from dirt. The boxes are arranged to be easily taken apart and stored when not in use.

An automobile foundry realizes that the operators do not take care of the machines or patterns properly, so when the day's work is finished, one man blows off, cleans and oils the molding machines. A second man cleans the patterns and puts a tarpaulin over the machine so the dust will

not get into the machines. These measures insure that the machines will be ready next morning for the scheduled production.

Foundrymen often operate equipment carelessly and then call for the maker to send an expert. The expert oils the machine, or renews a hose and the equipment is in service again. A competent master mechanic or upkeep man may reduce the number of useless trips of the manufacturers' experts. Often the foundrymen expect the equipment manufacturers to stand the expense of these trips.

When an automobile is stalled outside of town, the owner does not expect the garage man to tow it in without charge. The service expense of the foundry equipment manufacturers is one of the large items of the cost of equipment.

Equipment Men Eager to Help

The equipment manufacturers have experts traveling through the country, and for their own information, as well as to be of service to foundrymen, they would like very much to inspect from time to time the machines in service. They would do this gladly free of charge if they were allowed in the plants. Many purchasing agents do not allow the manufacturers' experts to examine equipment, even though in many cases thousands of dollars would be saved for equipment manufacturers and foundrymen if the experts were allowed to give needed assistance and advice.

With proper care, equipment lasts longer and the replacement costs are less. When equipment is not properly cared for, it may run a long time before it breaks down, but with a lowered output. The saving in labor costs effected by the increased production of all kinds of foundry equipment when operating properly more than pays for an expert maintenance department.

Promises can be kept; the product will be improved; labor costs will be reduced; the first cost of equipment will be reduced; and the life of all foundry equipment will be increased.

The Economical Control and Handling of Patterns in a Large Foundry

By WALTER D. JONES, Canton, O.

Every foundryman knows the problem presented in attempting to deliver the pattern and the core boxes to the foundry on time, correct according to the blueprint, and in relation to the promise date of shipment; to return them to the pattern storage the instant the foundry releases them; and to properly place them in the pattern storage section and shelf, where they will be found when wanted. The familiar sight of hundreds of patterns littering and cluttering up the passageways in and around the foundry and the oft-repeated abili as to why a pattern is there or is not there, as the case may be, is sufficient to recall to the mind of all the confusion which has existed and exists in most of our foundries today.

A complete description of the methods adopted at the plant of the Canton Steel Foundry Co. together with cuts and illustrations of forms, etc., appeared in the May 15 issue of *The Foundry*. Anyone whose interest is aroused in this brief outline of our pattern control system, is referred to the article mentioned. The photographs of the various forms used will help to make clear the explanation of our system here offered.

Offices Are Concentrated

The development of the plan made it necessary to bring together the various offices so as to co-ordinate the work. Therefore, a very important link in the chain is the arrangement of the offices of the superintendent, order, production, dispatcher and checker which are located in the main pattern storage building. The pattern shop is adjacent to the pattern storage building. The arrangement of these offices permits of easy access to one another with a minimum loss of time. Immediately outside of the checker's room is the active floor.

This is so called on account of the fact that here are stored all patterns which have been checked and sketched and which are waiting their turn to be sent to the molding floor of the foundry.

All blueprints are filed in the sketch room where they are available for reference. The official list of patterns is very much the same as that of other foundries and serves the purpose of locating the section and shelf where the pattern is stored. Before the order is written, the pattern storage section and shelf are shown on the customer's purchase order. This information is in turn copied on the regular order blank as well as the operation cards. If the index shows that the customer's pattern is not in storage, the production department is immediately notified, which in turn takes the question up with the customer and follows the matter until the pattern is received. The dispatch clerk is notified upon arrival of the pattern.

Movement of Patterns Through Plant

The cycle of movements of the patterns for each order are four. These movements are as follows:

First: The patterns are removed from the pattern storage to the sketch and checking room.

Second: The patterns are checked and sketched and removed to active floor.

Third: The patterns are transferred to the foundry to be molded.

Fourth: The patterns are returned to pattern storage section and shelf after being released in the foundry.

At the time the order is received it is known that each pattern called for on the order must go through these four operations and it seems to be the best practice to write the operation cards covering these movements at that time. These cards are then held until the order is ready to go into the foundry when they are released to the various departments as outlined in the following paragraphs.

How Operations Are Recorded

The method of recording these operations is as follows: The sticker (master copy) has provision for four orders, size 13 x 8 inches, the sheet being in effect four reproductions of

the same form separated by pin hole perforations. After the four orders are recorded the sheet is complete and is then used as a master copy on the duplicating machine for reproducing the other four copies. The forms, 6¼ x 4 inches, are then detached and made into sets. The sticker is further reduced, the actual size when placed on the pattern being 4 x 3 inches. Each set has five cards, four of which cover the movements of the pattern which comprise the cycle described in previous paragraph, and the fifth being a record card on which these movements are recorded.

Each of these forms contains the same information, including the date entered, job number, order number, name of customer, customer's order number, pattern number, storage, section shelf, description, quantity ordered, promised date of shipment, special steel (if called for), number of core boxes, and classification.

The operation cards referred to and the purpose they serve are as follows:

1. Pink transfer card. It routes the pattern out of the main storage. This card is replaced on the pattern after the pattern has been sketched and checked and remains on the pattern until the pattern is sent into the foundry. It is removed at that time and returned to the control desk and serves as a notice to the dispatch clerk that the pattern has been sent to the foundry.

2. Sticker.—The sticker is shellaced on the pattern after the pattern has been checked and sketched. By means of the sticker the pattern is identified on its arrival in the foundry by the foundry foreman and is assigned to the molder.

3. Mold Card.—This card is sent to the foundry clerk at time pattern is sent to the foundry. On it the time of molding the pattern is recorded.

4. Green Transfer Card Which Accompanies Mold Card.—This card is tacked on the pattern when the job is completed in the foundry by the foundry checker. It covers the return movement of the pattern to the pattern storage.

5. Pattern transfer record sheet which is kept in control desk.

The operation of the system is under the control of the production manager. It is in the dispatch office, however,

where the actual movement of pattern is controlled. The dispatcher keeps all operation cards in a desk which was designed especially to meet this particular problem. The desk has six filing units, and each unit has 24 leaves, four clips on each leaf. The lower section consists of four drawers divided into sections and provided with numerical tabs from one to 300,000. (Nothing below the even hundred is recognized in the index.) It first must be understood that each order has a promise date of shipment on it which is also shown on all of the operation cards. It is a standing order in our shop that the patterns must be sent to foundry and work started at least three weeks before shipping date shown on order, and unless definitely ordered otherwise, this procedure is followed. The dispatcher files all operation cards according to the date they must be sent to the foundry. Three days before this date the dispatcher releases the first operation card. This card is an order to the pattern storage foreman to send the particular pattern called for to the checking room. The dispatch clerk inserts the date in space provided on pattern transfer record and files it according to pattern number in the active pattern file.

Immediately after the pattern has been sketched and checked the chief checker obtains from the dispatcher the sticker and pastes it on the pattern. The sticker shows the number of core boxes and loose pieces required so that this important feature can be checked upon arrival into the foundry. At the time of checking, the loose pieces are nailed in proper places on the pattern. The dispatch clerk withdraws the record card, inserts the date pattern was checked and refiles the record card.

Outlining Provision of Patterns for Next Day

The pattern is then sent to the active floor where it waits its turn to be sent to the molding floor. Before the close of each day, the dispatch clerk hands to the pattern storage foreman a list of the patterns which are to go to the molding floors for the next day's work. This list is built up in diary form by the dispatch clerk currently. At the same time the dispatch clerk sends to the foundry clerks of the

various floors the corresponding mold cards together with the "return" card (No. 4 of the set, green). These cards are filed in the offices jointly occupied by the foremen and foundry clerks of the respective molding floors so that the foremen and clerks know at all times the work in hand and ahead, and can plan accordingly. As the patterns are tallied out into the foundry the dispatcher inserts the date on the corresponding record cards. The dispatcher is able to get an absolute check as to whether the pattern storage foreman has sent the correct number and the right patterns into the foundry by means of the pink card (No. 1) which remains on the pattern until the pattern is sent into the foundry and is then detached and returned to the dispatch clerk who in turn checks it with the daily list, to see whether the work is properly performed.

As fast as the patterns are released by the foundry they are returned to the pattern storage, and on arrival there, they are returned to the proper section and shelf. The green card is then detached and forwarded to the dispatch clerk who again refers to the record card and inserts the date that the patterns were returned to storage and removes the record from the active pattern file. This card is then sent to the production office where it is filed according to pattern number as a permanent record. All of the other cards are destroyed as the operations are completed. This completes the cycle.

Advantages of Filing System

One word in regard to what is accomplished by filing the record card according to pattern numbers. In the opinion of the writer, it is important to have some method of bringing together by pattern number, all of the orders on which the pattern must work. This method insures that the pattern is molded in sequence according to the production schedule and promise of shipment date. Moreover the pattern is not returned to storage until the production cycle for orders in hand calling for this pattern are completed. Also, by this method, it is possible to plan in advance for changes which are sometimes necessary to make on the pattern.

Under the plan the dispatch clerk first files the record card by pattern number. He is therefore immediately in pos-

session of the vital information as to whether the pattern is tied up on other orders; whether the volume of orders calling for a particular pattern warrant the making of an additional pattern; and which of all the orders calling for the pattern should be given priority. In addition, the active pattern file reveals automatically the active orders in the foundry, the date the patterns were sent to the foundry and the order became active, and the location of the pattern at all times. This file record is a very simple one and can be expanded to take care of an unlimited number of patterns.

Much of the lost time in foundry production is directly traceable to improper and careless handling of the patterns. What this company has attempted to do is to reduce the problem to a standard practice. The best proof that can be offered as to the merit of the plan outlined in meeting the problem at this plant lies in the different attitude of the men who do the work. We now have intelligent direction, awakened and keen interest, and mind work instead of tongue work. We get facts instead of alibies.

How to Secure Best Results in Combining Hoisting Apparatus With Molding Equipment

By W. C. Briggs, New York

In preparing this paper, the writer's underlying thought has been to suggest a means for solving some of the difficult problems of foundrymen who are trying to systematize their work and costs; to assist in placing the work in the foundry in the hands of the man who will produce the largest tonnage of any particular class of work; to aid in the difficult problem found especially in jobbing foundries of trying to make castings from patterns from which only a few castings are required on molding machines; and also to distribute the work in the foundry where the crane or hoist facilities are best suited for handling the work.

Foundries can be divided into at least four distinct types, namely, gray iron, malleable iron, steel and bronze and aluminum. Each type can be classified into a number of types based on the size and kind of castings made. Many foundries of each classification may make castings of a similar character continuously. Even in this class of foundry the system outlined in this paper can be applied with some degree of helpfulness.

It is a comparatively simple matter for engineers to design and lay out a foundry to make the same kind of work continuously. The scheme outlined is intended to suggest methods that will assist the larger number of foundrymen who make a variety of sizes and weight of castings.

Labor is Big Problem in Foundry

The question of labor cost is more and more becoming a big problem with all foundrymen and exists from the time the raw materials arrive until the finished castings are loaded. In order to reduce the number of common laborers

to a minimum, designers give entirely too much consideration to the handling of raw materials, loading of castings, etc., where the total pro rata cost per ton is a much smaller factor than the skilled workman's time on the molding floor.

This, of course, is not true in all cases, but is apt to be true in the case of the jobbing foundry where the owner or engineer has in most cases failed to find a means for making a layout of the foundry with foundry floors, cranes, hoists and molding machines so combined that they are adapted to handle to the greatest advantage a predetermined class of work.

If, however, each pattern when received is placed in a definite classification as outlined in the following table it will be possible to use hand molding and hand lift where it can be used with the highest efficiency, and hand molding and crane equipment where it will be more efficient, and likewise machine molding and hand lift where these factors can be combined to produce the largest tonnage.

		Hand Molding		Machine Molding	
Class	Size of Flask	Hand Lift	Crane Lift	Hand Lift	Crane Lift
1	18 x 18 x 6	1—HMHL	1—HMCL	1—MMHL	1—MMCL
2	18 x 18 x 12	2—HMHL	2—HMCL	2—MMHL	2—MMCL
3	24 x 24 x 6	3—HMHL	3—HMCL	3—MMHL	3—MMCL
4	24 x 24 x 12	4—HMHL	4—HMCL	4—MMHL	4—MMCL
5	24 x 30 x 6	5—HMHL	5—HMCL	5—MMHL	5—MMCL
6	24 x 30 x 12	6—HMHL	6—HMCL	6—MMHL	6—MMCL
7	36 x 36 x 6	7—HMHL	7—HMCL	7—MMHL	7—MMCL
8	36 x 48 x 8	8—HMHL	8—HMCL	8—MMHL	8—MMCL
9	36 x 48 x 12	9—HMHL	9—HMCL	9—MMHL	9—MMCL
10	48 x 48 x 8	10—HMHL	10—HMCL	10—MMHL	10—MMCL
11	48 x 48 x 12	11—HMHL	11—HMCL	11—MMHL	11—MMCL
12	48 x 60 x 12	12—HMHL	12—HMCL	12—MMHL	12—MMCL
13	60 x 60 x 12	13—HMHL	13—HMCL	13—MMHL	13—MMCL
14	60 x 72 x 12	14—HMHL	14—HMCL	14—MMHL	14—MMCL

Tag Patterns According to Classification

The writer has not intended to carry this classification into all the sizes of flasks or depths of cope and drag that some foundries no doubt find it advisable to classify, but sufficient to outline the general scheme. The plan proposed is to place this classification list in the hands of the patternmaker or the man who has charge of the flasks so that suit-

FIG 1—THE WORK NOW HANDLED BY THIS CRANE FORMERLY WAS HANDLED BY A JIB CRANE. PRODUCTION WAS INCREASED 4 TIMES BY THE USE OF THE CRANE SHOWN

able tags or stencilled markings may be applied to the pattern.

Tonnage of castings is very largely influenced by the ratio between the size of the flask and the weight of the casting and the cost of molding follows in much the same ratio. Therefore with a system of this kind, the matter of setting the price is simplified. For instance, if a casting weighing 50 pounds is produced in classification No. 1, the same casting produced in class No. 2 would cost more, and by keeping the cost of castings made by each classification, a table soon could be prepared that would be of great assistance in estimating the cost of making all kinds of castings.

Size of Flask Influences Cost

Of course there are many other elements that enter into the cost, but most of these elements do not influence the price anything like the ratio between the size of flask, which governs the amount of labor to a large extent. It is realized that green sand and dry sand molding costs vary, and that the kind and size of cores are important elements.

These classifications also will help to solve the cost problem which has been found so difficult in foundries turning out a large variety of work. It is a well known fact that there is a limited amount of foot pounds of work for every man. It varies somewhat with the man, but just as sure as a man's energies are properly applied, just as sure will he produce more and better results. If it is necessary for a molder to go to the pattern loft or flask shop to get his pattern and then to select or fit up a flask or assist the pattern maker or flask man to do so, and then get his floor ready, cut up his sand, find the necessary rigging, gagers, etc., he is not going to get started to make his job with as much dispatch as he would if a system was used whereby these factors were taken care of in a systematic way. There may be some work that can be rammed by hand or by treading in with the feet at as low a cost as can be done by any other method, but such jobs are few and far between and a good skilled mechanic should never be used for that kind of work.

FIG. 2—CENTRAL BAY OF FOUNDRY SERVED BY CRANES ON HIGH AND LOW RUNWAYS. THE THREE CRANES OPERATING ON THE LOWER LEVEL ARE USED IN CONNECTION WITH MOLDING

Many factors contribute to securing the best results The old foundry with its low roof and dark interior, where it is necessary to use the tallow candle to see to finish the mold and set the cores, is fast disappearing because it cannot be operated in competition with modern properly lighted foundries equipped with good handling facilities.

As many modern foundries are designed light is the main consideration. Those that make a large variety of work from castings weighing a few pounds to those weighing several tons frequently do not have facilities for handling the kind of work they are to make. Often no attempt has been made to establish even approximately the floor area required or handling facilities best adapted for the particular kind of work to be made because the designer did not have a clear conception of the size and weight and volume of each kind of casting to be made. If, however, the pattern is classified when received or made, into the size of flask which automatically establishes the approximate volume of sand and weights to be handled, the problem of designing the building, distributing the work, providing molding machine and crane equipment can readily be solved.

In the past the handling apparatus, whether overhead traveler, jib crane or monorail hoist has been considered as a necessary evil or an auxiliary equipment instead of being considered as a great aid in producing maximum results providing the handling equipment is selected to serve the particular operations required.

The work shown in the foundry, Fig. 1, was formerly made under a jib crane. Three men had to put in a long hard day to produce nine or ten molds. This job was fitted up to be made on a molding machine and an electric traveler arranged with controllers operated by pendant cords designed so that any one of the men in the gang could handle the flask to the molding machine and mold to the floor was provided. After one man had placed the cores, another could operate the traveler and close the mold, two additional men were added to the gang making five men to serve the molding machine, set the cores and close the mold. The men produced 44 molds for a day's work and did not work as hard as with the old

FIG. 3—MATERIAL STORAGE YARD OF FOUNDRY WHOSE INTERIOR IS SHOWN IN FIG. 2. MATERIALS ARE HANDLED BY THE CRANE AND MONORAIL HOIST SHOWN

combination, producing less than one quarter of the number of castings.

Fig. 2 shows a foundry with a central bay served by travelers placed on two levels. On the lower level are three 3-motor electric cranes, arranged for control by pendant cords from the floor, each crane having a capacity suitable for handling the largest mold to be made, but not largely in excess of the capacity required. On the higher level the cage-operated machine is of higher speed and is used largely for distributing flasks, taking out castings, and when necessary, carrying large ladles of iron over the top of the lower cranes without interfering with the molding operations. The side floor of this foundry is equipped with two 2-motor electric travelers, arranged for control by pendant cords. These machines are of light capacity, designed to perform the particular operations required of them. The core room, extending the whole length of one side of the foundry is served by a light capacity quick-acting overhead traveler.

System is Factor in Production

The crane equipment in this foundry is nearly ideal, but by applying the system of classification of pattern and by making a study of the average number of castings made in definitely established flasks and by selecting the best molding machines for the work, a much larger tonnage could be produced with the same number of men. While the item of handling materials is low per ton of castings produced, many foundries are operating with high costs that can be lowered economically by the application of properly selected handling equipment.

Fig. 3 shows the material storage yard of the foundry shown in Fig. 2. Pig iron, coke, sand, etc., are moved mechanically throughout. Pig iron is unloaded from the cars by magnet to the yard and as required delivered to the charging platform by the crane and monorail hoist, clearly shown in the illustration. The only man labor is used in charging the cupola from the scales located on the platform. The sand and coke is unloaded by gravity to bins beneath the trestle.

Efficiency engineers have done much to lighten the burden of the manufacturer and the man who does the work but it is no easy task to get these parties thinking along the same lines. The writer had this thought in mind many times as he observed the operating conditions of foundries visited during his 12 years' experience calling on them in connection with applying electric cranes and hoists.

Very many foundries, especially the jobbing foundries, can greatly increase their production and make the job easier for both owner and workmen by giving more careful study to the pattern before it goes to the foundry and by standardizing flasks and then alloting as far as possible, definite floor space, suitable handling facilities and molding machines for the work.

Foundry Sand Handling Equipment

By H. L. McKinnon, Cleveland

The present tendency toward quantity production in the foundry has opened the way for more economical methods of handling the sand, and it is of these more economical methods that this paper will treat.

The problem of sand handling in a foundry is one which rapidly increases in importance as the quantity of sand to be handled increases. This can be well illustrated by considering a foundry with a few men, making castings in a limited quantity, almost wholly by hand. In such a foundry the problem of handling the sand is simple. Enough sand may be placed on the floor in front of each molder so that he can do his full day's work and pour off his castings, and the sand may be returned to him after the day's work is done.

Why Mechanical Handling is Necessary

When large production is in process, and many tons of sand are to be turned over daily, the cost of physical labor alone runs up into such large figures that it is essential that mechanical means be found to reduce the expense. The advent of the molding machine into the foundry, and the consequent increase in the productive capacity of the molder has still further added to the burden of handling sand by manual labor and has made it necessary, from an economical standpoint, to provide for mechanical sand handling. Foundries of a continuous character present additional problems which add still further to the difficulties of handling the sand manually.

The use of sand in the foundry divides itself into two main elements; that of making molds and cores. It is further subdivided in accordance with the class of material to be poured in the molds, such as gray iron, brass, aluminum, malleable iron and steel. Each of these divisions is still further

FIG. 1—VIEW OF GRAY IRON FOUNDRY WITH COMPLETE MECHANICAL SAND HANDLING EQUIPMENT

subject to minor divisions depending upon whether the work is heavy, or medium, or light.

The different qualities which are necessary for the various classes of work are so well understood by foundrymen as to need no explanation here. However, in order to properly understand the problem of foundry sand handling it is necessary to have some idea of the character of the work for which the sand is being used. For light castings of gray iron, brass and aluminum, the sand should contain a high percentage of clay as a binder, whereas the requirement for steel castings is a sand which is almost pure silica, with the addition of such materials as will give it the proper consistency for the work in hand. As malleable iron requires somewhat higher temperatures than ordinary gray iron, the sand for this work should contain a trifle more silica than is necessary for gray iron castings.

Screening and Treating Sand

Given the proper sand for any particular class of work, the first operation is the proper screening and treatment of the sand, so as to enable the molder to use it in the production of castings. The manual processes in use for many years consist principally of the addition of water to the sand on the floor of the foundry, either before or after hand screening, and then the cutting over of the sand with a shovel or other tool, and allowing the sand to stand over night so that the water became thoroughly associated with the various particles by capillary attraction.

This method requires considerable floor space for the storage of sand, and usually makes it necessary for the sand to be worked over by a night force after the day's product has been poured. It also involves the shoveling of the sand many times before it is placed in the mold. Such methods cannot be economical in foundries of large production which handle many tons of sand every day.

The mechanical problems to be met depend very largely upon the nature of the work to be done, and whether or not it is desirable to reclaim the core sand as well as the mold sand. Different problems are encountered in handling dry sand molds

and in handling green sand molds. The most of these problems are essentially similar in that the sand is of such a nature as to render it practically impossible to divert it from one place to another by means of chutes. The sand must be picked up and carried from one place to another. It must be thoroughly cleaned. The proper amount of moisture must be added,

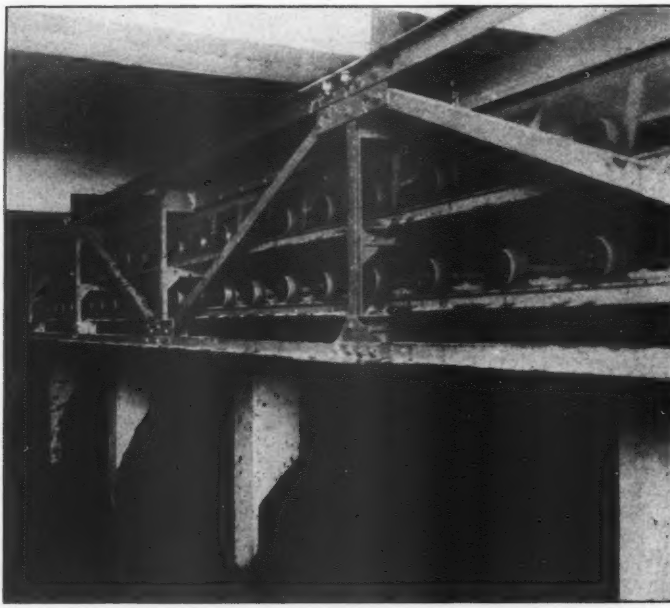

FIG. 2—CONVEYOR UNDER FOUNDRY FLOOR FOR REMOVING USED SAND

beaten thoroughly into the sand and then allowed sufficient time for final, even, distribution throughout the mass.

Equipment for Gray Iron Foundry

Various mechanical methods are being used for handling sand in foundries. Fig. 1 shows the interior of a foundry engaged in casting light gray iron parts, practically all of which are being made in snap flasks of such size as to be readily handled by one man. In this particular installation molding

machines are operated in pairs, about 6 feet 6 inches apart, one molder working on a drag and the other on a cope for the same job. As rapidly as molds are made they are laid out on the floor directly back of the molders, where a separate pouring crew attends to the pouring of the metal and the shaking out of the molds.

In order to facilitate the prompt return of the sand in this installation, a pan or apron type conveyor runs underneath the floor of the foundry extending the entire length of the center of the molding bay. Over this conveyor, at intervals, there

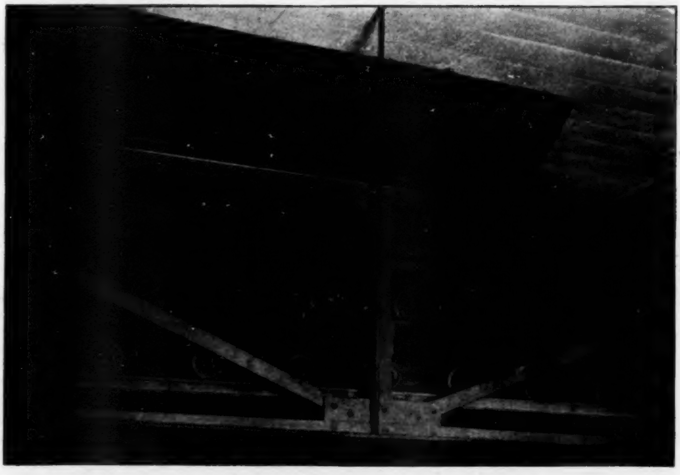

FIG. 3—CLOSE-UP VIEW OF USED SAND CONVEYOR SHOWING HOPPER FROM FOUNDRY FLOOR

are receiving hoppers and on top of the hopper there are gratings to prevent castings and matter other than sand from getting onto the conveyor.

The conveyor delivers the sand to what is called the scalping or roughing screen which removes pieces of coke and such small foreign substances which get into the sand. The screened sand then drops into an elevator and is carried to the top of the treating building where it is again screened. After screen-

ing, water is added and the water and sand are thoroughly milled in a centrifugal machine which produces a uniform product.

The control of the water supply is in the charge of an operator who is held responsible for adding the proper amount to put the sand in ideal condition. From the milling process the sand drops into a storage bin where it is allowed to rest for a definite period in order that capillary action may take place and the moisture become thoroughly distributed through the particles of sand. From this point the sand is fed onto

FIG. 4—SCALPING OR ROUGHING SCREEN FOR PRELIMINARY SCREENING OF USED SAND

belt conveyors and distributed to the molders, the hopper for each molder being placed above his machine, so that he can drop the sand directly on the mold if he desires. Fig. 5 shows the gate and hopper used in the installation which has just been described.

Molds May be Handled Mechanically

This is by no means the only method which can be economically followed in the handling of sand. Frequently it becomes desirable to convey molds for pouring either on a conveyor, or on cars, or by other means, to a central pouring station and from there to a dumping position where the hot

sand is disposed of in the same manner as outlined in the foregoing description.

In one large foundry in which there are two screening and treating plants, the equipment is provided with four knockout positions. The molds are brought to the knockout positions after pouring, by traveling cranes. The sand is jarred

FIG. 5—FINAL SCREEN AND CENTRIFUGAL TEMPERING MACHINE

out of the flask by means of heavy jarring machines, which are essentially similar to the jarring machines used for molding operations. The sand then falls onto the pan conveyor and is carried through the same process of treatment and screening as described above.

FIG. 6—ROW OF OVERHEAD SAND HOPPERS WHICH SUPPLY SAND TO MOLDERS AS NEEDED

In the handling of molding sand, a few important general principles should be kept in mind. It is never desirable to handle tempered sand in a bucket elevator if other means can be used. The reason for keeping away from the bucket elevator for this service is that the tempered sand has a tendency to fill up the buckets and requires frequent cleaning in order to maintain the operating capacity. If the sand is handled

FIG. 7—INDIVIDUAL OVERHEAD SAND HOPPERS

as it comes from the molds it is generally dry enough so as not to involve this difficulty.

Advantages of Flat Belt Conveyor

For the distribution of the tempered sand, in my judgment, there is nothing so satisfactory as the flat rubber conveyor belt, even though reciprocating flight conveyors have been used with more or less success. One of the main objections to the reciprocating conveyor is the amount of power required to operate it as compared with the belt conveyor. A further objection is that there is a marked tendency to produce small balls of sand about the size of peas or beans which are detrimental to the obtaining of smooth castings.

The use of the rubber conveyor belt is strongly recommended because of the fact that it possesses a smooth operating surface which cannot become impregnated with the sand and which resists wear for a long period. The writer recently viewed a belt of this character which had operated through the equivalent of 9 years continuous daily service. The belt is

FIG. 8—TEMPERED SAND STORAGE BIN SHOWING CUTTING SAND FEEDERS

240 feet, center to center, and handles approximately 250 tons of sand daily. It has been operating for 7 years but during the years 1917 and 1918 worked double shift. At the time it was viewed by the writer it was still in good working condition.

The device for removing the tempered sand from the belt conveyors is extremely simple and consists of nothing more

than a curved plate placed so as to act like a plow and turn the sand over at the desired point. These plow plates are hinged at one end so that they may be lifted out of the way, allowing the sand to pass to any other desired point.

Removing Sand from Storage Bins

One of the principal difficulties which has been met in foundry sand handling has been the problem of properly with-

FIG. 9—FLAT BELT CONVEYOR FOR DISTRIBUTING TEMPERED SAND

drawing the tempered sand from the storage bin after it has been placed there. Many expedients have been used but it is the writer's opinion that the type of feeder shown in Fig. 8 meets the condition more satisfactorily than any other with which he is familiar. It is easily adjusted and seems to have

the peculiar motions which are best adapted for cutting the sand and removing it from the bin in a regular manner.

Another problem presents itself in the handling of core sand, after castings have been poured. Fig. 10 shows a device placed in the cleaning room of a large gray-iron foundry for the purpose of separating core rods, nails and other magnetic materials from the core sand itself. The first belt shown

FIG. 10—MAGNETIC SEPARATOR AND WASTE SAND CONVEYOR

in the illustration is provided with a magnetic head pulley so that the metal is dropped on the floor while the sand is delivered onto the belt which runs out of the building. The waste sand can be taken to railroad cars outside, or to a storage bin, or to trucks, or to a storage pile. The magnetic pulley does the work of several men in picking out magnetic materials, and does it cleaner and better.

Mechanical sand handling is entirely practical where the quantity of sand is great enough so that the cost of conveyor equipment, as an overhead expense is not too great. In

general it seems to be possible to put in a sand handling equipment on duplicate work where there is a minimum of 150 to 200 tons of sand to be handled daily. In some instances where the work is highly concentrated, a much smaller amount of sand than this can be handled economically.

The frequency with which molding sand may be re-used depends primarily upon the dryness of the sand before tempering, that is, if very light castings are being made and the temperature of the sand is not greatly increased, such sand can be used more frequently than that which becomes highly heated.

To my mind the problem of sand handling is simple. The less apparatus that can be used to accomplish a given result is in most cases the most satisfactory. This is due partly to the difficulty of obtaining proper mechanical attention to equipment in most foundries; but without proper mechanical attention there is no equipment that will prove satisfactory and give continuous service. In considering mechanical equipment it is extremely desirable that the question of mechanical attention be fully considered.

There is no reason why mechanical sand handling equipment cannot be produced to meet any set of conditions, providing there is sufficient sand to handle to justify the initial expense. If properly arranged, mechanical sand handling equipment should result in increased production per square foot per man on any given floor space. This has been demonstrated repeatedly. Ample proof in the form of many successful installations is available for anyone who cares to investigate.

Discussion

STAUNTON B. PECK.—In 1889 Thomas Welsh, superintendent of the Westinghouse Air Brake Co., conceived the idea of continuous molding, the molder never moving from his machine. In conjunction with the writer, a plan was worked out and the necessary conveying equipment installed the following year in the company's foundry at Wilmerding, Pa.

The molds as made were placed upon a continuously moving conveyor which carried them to the cupolas where they were poured, thence to the shake-out where the castings were picked out and taken to the mill room. The sand was riddled, tempered and elevated to an overhead conveyor running above the molding machines and delivering to them through down spouts. The returning run of the mold conveyor restored flasks, bottom boards and weights to the molders, and a separate conveyor above this brought the cores from the core room to them.

The main advantage sought was economy of labor in handling the great quantities of materials in this large foundry; but there were two other incidental features almost as valuable. The molders were relieved from the part of the ordinary molders' duties requiring least skill and were enabled to give their entire time to molding. Pouring, shaking out, tempering, etc., were performed by independent gangs, each thus attaining the highest proficiency in their special duty.

Each molder and helper put up regularly 60 flasks per hour and 600 per day; and in a foundry which had already attained a very high degree of efficiency in ordinary methods of operation and was on a piece work basis, a saving of ½c per pound was effected. This was a very large saving under the circumstances and at that time.

The other incidental advantage was the saving of room or a great reduction in the area of building needed for the required output. This can readily be appreciated as each molder required no "floor" for the accumulation of his molds before pouring. In a foundry somewhat similarly equipped some years later, I was told by the architect that the cost of the conveying system, about $80,000, was considerably less than that of the buildings required to give the additional floor area providing a conveyor system was not installed.

The Westinghouse plant was the forerunner of many other continuous or semicontinuous systems which have been installed.

The general principles are the same as described, though in some cases, where the molds are relatively large and heavy, it has been found more desirable to bring the iron to the mold

as soon as made, conveying away the large castings as fast as shaken out.

With the development of the continuous system, where the sand is used over and over again during the day, it has been found essential to give special attention to the cooling of the sand and to its preparation or conditioning.

In some cases the normal conveying of sand on belts of sufficient width to spread it thin is sufficient; in others special aerating devices are used.

The continuous use of sand is usually found to result in its becoming granular, in the formation of minute pellets, and the loss of bond. This is not peculiar to the reciprocating conveyor alone as Mr. McKinnon suggests and which others have concluded from the action of that conveyor which suggests rolling. It occurs in the same degree in systems where there are no such conveyors or even only belt conveyors. Long and close observations show it to be due to the cumulative action of chutes, screens, conveyor, riddles and molds, without time for the moisture to thoroughly and completely permeate the mass and make it perfectly homogeneous. It can be observed in ordinary molding if a relatively small amount of sand is used over and over again during the day's work. It can be wholly corrected and sand in perfect condition for molding produced by passing it through grinding pans, rolls or special devices designed for the purpose. A good example is a revivifier which is essentially a series of blades revolving at very high speed. The pellets are destroyed by impact and a perfect mixing and homogeneity obtained at the same time. It is an indispensable feature of most of the continuous systems now in successful use.

Mr. G. K. Hooper.—It always has seemed an economic wrong to laboriously handle by crude methods once a day a tonnage of sand equal to from four to ten times the tonnage of castings produced, it being apparent that by re-use during the day and by improved methods both the total quantity of sand and the labor spent upon it can be greatly reduced. The application of labor-saving methods to sand handling is, however, as in all other things, limited by the conditions surround-

ing any particular product and each case must be studied upon its own merits.

The statistics given by the author as to minimum tonnage of sand to which handling methods can be profitably applied are misleading, as is the statement concerning saving of floor space. The tonnage handled has, as a matter of fact, but an indirect relation to the savings to be made, the mold being, in my judgment, the unit on which any consideration of sand handling economies should be based. This will become apparent when it is realized that the economies to be made are based on the time saved in making the mold. If the depth of the mold be constant, the length and width make but little difference, as the sand chutes can be adjusted to suit. Also a considerable difference in the amount of sand handled will make but slight difference in the installation and operation cost of a handling system. The tonnage is therefore an entirely unreliable guide.

Minimum is 5000 Molds Daily

I have in the past figured a number of proposed installations, the calculations developing that at prewar prices a production of approximately 5000 molds per day is the minimum basis for installation of such a system. At present prices of apparatus this figure would be somewhat increased, depending upon the relative increases in cost of apparatus and of labor.

Where properly applied such apparatus increases the productivity of foundry labor from 15 to 25 per cent.

In the author's statements concerning saving of floor space he has mistakenly credited the sand handling apparatus with such a saving. Any investigation of plants to which the author refers will undoubtedly reveal that some improved rapid casting method was simultaneously installed and that the saving in floor space is undoubtedly due to the latter. As a matter of fact, the installation of a sand handling system alone would require an increase in floor space since a greater number of molds could be made per day and additional floor space would be required for the increase. Floor space can be saved only by rapidly taking away the molds made.

As to the apparatus itself, it is surprising to find devices

described by the author which have been proved by long experience in sand handling to be unnecessary and in fact detrimental from an operating point of view.

Second Screen Deemed Unnecessary

These are a second screen for removing foreign matter and a storage tank for the diffusion of moisture through the sand. It is possible to say without reserve, based on an experience of nearly 20 years in the design and operation of such apparatus, that one screen can do all of the necessary cleaning for any handling system even for sand used on delicate work requiring fine surface, and that the introduction of a second screen serves no useful purpose.

The storage tank also is proven by experience to be unnecessary. It is at best but a resultant of trade tradition and conservatism. There are a number of successful systems in operation over long terms of years without such a storage tank, some of them designed by me, in which the sand is cleaned, cooled, tempered and used again in the mold in about 20 minutes from the time of shaking out, with a very low casting loss. The storage tank, as the author rightly points out, introduces complication through the necessity of feeding devices and it has also other operative drawbacks, to say nothing of its original cost.

I agree with the author as to the disadvantage of carrying tempered sand in a bucket elevator and also as to the faults of the reciprocating type of conveyor. The action of the latter in "balling" the sand is well established by experience and it has also the defects of gradual reduction of capacity through wearing of the paddles or flights and a tendency to become inoperative through flooding or temporary overloading due to momentary derangements elsewhere in the system. A flooded conveyor practically always means a stoppage with consequent time loss and a dirty, inconvenient job of cleaning up.

Equipment for Sand Distribution

In the matter of sand distribution to molding stations, experience has, in my judgment, proved the flight conveyor to be far superior to the combined belt and plows advocated by

the author. The latter is a crude device requiring attention from an operative for keeping the hoppers and chutes supplied and the surplus sand properly disposed of. Such a belt is also subject to spill, thus involving the necessity of cleaning up. Further, it will not, without assistance, take care of flooding.

The flight conveyor is open to none of these objections as it distributes sand automatically to the chutes through holes in the bottom of its trough, it keeps its trough clean, removes surplus sand without attention and automatically takes care of flooding.

Too much support cannot be given to the author's statement of the necessity of competent mechanical supervision of such apparatus. Being a machine of considerable magnitude and an essential link without which all the other molding operations cannot proceed, it is of the utmost importance that it be properly attended. A competent machinist or millwright usually develops sufficient skill to keep such an apparatus in proper operating condition, and such a one should be put in charge of and made responsible for the mechanical operation of the apparatus. Such a man can usually develop sufficient skill also to be made responsible for the condition of the sand, thus removing this task from the shoulders of the foundry foreman and removing also any chance for conflict of responsibility between the mere operation of the apparatus and its proper functioning as a sand conditioning device.

The Value of a Scrap Pile

By Henry Traphagen, Toledo, O.

Defective castings—the tenants of the scrap pile—offer to the discerning and ambitious foundryman knowledge that is beyond price. Show the foundry expert the scrap pile, and he will tell you the caliber of the foundry, for evidence of either constructive progress or the senseless repetition of blind ignorance, is indelibly and relentlessly stamped on that tell-tale pile of rusting iron.

It all depends upon whether the defective castings are intelligently examined or whether they are buried away under old barrels, what the real value of the scrap pile will be to the foundry. Intelligently examined and constructively criticized, a defective casting will invariably point out the antidote; but if it is hidden away and treated as an enemy rather than a friend, it means that casting after casting will be turned out in the same old way; the customer will be dissatisfied; the foundryman will have made no progress; and the establishment itself will finally rest in the financial scrap heap.

The up-to-date foundry should have at least one competent, experimental molder, who is paid by the day, and not hurried; his business is to investigate the proper method of gating and heading castings as they come into the shop. Every department is interested, every responsible department head lends his bit to the fund of general knowledge. The work of the experimental molder is thoroughly examined, and discussed. If consistent and concentrated effort is made, it will be but a short time before the experimental molder is turning out a sound casting.

He May Go To China

When the casting comes right, then it should be either sketched or photographed with the gates and heads attached,

and a permanent record made. If the same job comes back a year or two later it is immaterial whether the experimental molder is in China or the superintendent in parts unknown—that casting can be made again, for the proper method of making it is on record.

It would appear at first sight that experimental molding would be an almost endless task; that the experimental molder would have to start out on an entirely new tack every time a casting came into the shop, and that the number of records necessary would be almost overwhelming, but if foundrymen will carefully investigate this method of experimental work, they will find that after all, the number of real basic defects that are found in castings are comparatively few. They will discover that castings naturally group themselves into a few well defined classes, and that each class is subject to characteristic defects that are easily recognized, and in a short time they will learn to discount possible defects at the start.

If the foundryman can grasp the broad conception of castings as a whole; if he can master the few fundamental laws of solidifying metal, he will have made no small measure of progress toward the desired end. But unfortunately, it seems to be the common impression that the various branches of iron and steel founding are peculiar, each to itself; for instance, the malleable man imagines that his troubles are quite distinct from those of the gray iron shop; while the gray iron founder is under the impression that gray iron and semisteel obey laws that were designed especially for that class of work; and it is sometimes amusing to hear the steel man dilate upon the peculiar and mysterious troubles of the steel business.

Now if the foundryman will only recognize the fact that all these various metals are alloys of carbon and iron; that they all merge one into the other without any sharp line of distinction; and furthermore, that they all in general obey the same laws, then, the great light will dawn upon him that there are but few real basic troubles in a foundry.

Several fundamental difficulties that are found in foundries have been described in the literature on the subject; but unfortunately these descriptions seem to be lost in a maze of papers dealing with the various peculiarities of chemical ingredients, new fangled methods of chemical analysis, long discussions on grain aggregates, and in fact, everything under the sun, except a frank, plain discussion of the foundryman's troubles. It is because of the great difficulties in wading through a mass of literature that the average foundryman has become disgusted with chemists and scientists in general; and judging from the impractical, high-brow contributions that they have given later-day literature, it would appear that the foundryman's disgust is well founded.

If the foundryman will carefully study his defective castings the writer believes that he will ultimately agree that all of the defectives can be traced to one of a very few fundamental errors. In general, these fundamental errors may be summed up as follows:

First.—The personal equation, or in other words, the carelessness of the workman.

Second.—Over-production, which puts a premium on careless, sloppy work.

Third.—The attempt to make good material out of junk.

Fourth.—False economy, which results from the use of too little fuel, too much scrap, cheap refractories and too great a reliance in green sand molding.

It has been the writer's experience that of all troubles in the foundry, about 10 per cent can be traced to the melting department and the other 90 to the molding department.

To produce a good casting from any kind of iron or steel, it is absolutely essential that the metal be hot and fluid. But unfortunately, hot, lively metal is not as common in our foundries as one would be led to expect, and the causes of cold metal may be briefly summarized as follows:

The bed in the cupola may be too low. This is a very common error and generally results in cold, sluggish metal. It is a simple matter to determine whether or not the bed is low. Leave the tap hole open, turn on the blast, and note the

time that it takes for the first metal to run over the spout. If iron appears in less than 10 minutes, it is almost a certainty that the bed is too low. A low bed means dirty, porous, weak castings, because of the metal melting directly in front of the tuyere blast and becoming unduly oxidized.

Another prolific source of cold metal lies in the attempt to conform to a prearranged melting ratio. In the dictionary of common sense there is no such word as melting ratio. The correct melting ratio is the amount of coke that will give hot, fluid metal; and this amount of coke will vary with the size of the cupola, the amount of scrap used, the kind of coke, the percentage of steel used in the mixtures, and the size and condition of the sprues. It is therefore evident how ridiculous it is for anyone to attempt to lay down a specific melting ratio for cupola practice.

Cold metal in the converter can generally be laid to one or two causes. In the first place the metal in the cupola may be cold for one of the reasons just enumerated; the percentage of silicon may be too low for successful blowing, or what is most common, the lining of the converter may be too wet, or there may be a leak either in the wind chest or somewhere along the line. It is rarely found that cold metal can be traced to a variation in chemical content, and before the foundryman wastes any time fooling around the laboratory, it is far better that he examine his cupola practice, his converter linings and his wind apparatus.

Another Cause for Cold Metal

There is another great fundamental cause for cold iron, and this cause operates not only in the cupola, but in the converter, the air furnace, the open-hearth furnace, the crucible furnace and even in the electric furnace.

We refer to the effects of oxygen, or as it is commonly called, oxidized metal. There is no disputing the fact that foundries very frequently receive shipments of pig iron that will not produce hot iron, no matter how careful the melting practice may be, and such iron is delivered much more frequently than the average foundryman has any idea of. It is

useless to check up the analyses of such material, for the blast furnace laboratory report will in nearly every case be correct, and the fact that it is correct furnishes the chief alibi for the furnace.

Pig iron is sold on chemical analysis only, and it is presumed that if the analysis conforms to the customer's requirements the iron must necessarily be satisfactory, but nothing is further from the truth in my judgment. The pig iron that generally causes such a long train of disagreeable troubles, such as porous castings, skulled ladles, bunged-up cupolas, etc., is a product of over-production; the furnace people may not be able to write a learned, scientific explanation of this phenomenon, but they know when such iron is made and they also know to whom the iron is sent.

The furnace people know when they have what is called an off-heat, and they also know that these off heats are caused by badly worn furnace linings, the use of coke breeze, the use of scrap and turnings in the charges, or the attempt to smelt a very refractory ore, such as magnetite. It appears that such off pig iron is caused by the presence of oxides dissolved in the metal and it is probable that the most prolific source of this trouble is due to undecomposed ore, descending into the hearth and dissolving in the metal.

The average foundryman is not interested in the theory of this condition, but he is, or should be vitally interested in being able to pick out such defective irons. Oxygenated pig iron is generally full of gas and dirt; almost invariably upon breaking the pigs, a large gas cavity will be found in the interior.

If, on breaking a shipment of iron you find that it is consistently unsound and full of gas cavities, reject that iron if you can possibly get away with it. But if the furnace absolutely refuses to take such iron back, which is too often the case, then the only recourse left to the foundryman is to hold the shipment in the yard and use it very gradually, say one pig to a charge, until the pile is gone.

Defective pig iron seems to be getting more common every day; the writer has found it in practically every kind of a

foundry, ranging from malleable iron up to steel. The furnaces will continue to ship such iron just so long as the foundryman is content to buy by chemical analysis, and chemical analysis alone.

The Effect of Rust

Another source of cold, sluggish iron and steel lies in the use of thin, dirty, rusty scrap. Such material as rusty flashings, turnings, shearings, punchings and other fine voluminus scrap has no place in the melting furnace, if the melter expects to get sound, healthy metal. Such scrap is being used literally by thousands of tons in our open-hearth furnaces today. It is common in steel foundries, malleable shops and gray-iron foundries. But the result is the same, no matter what type of furnace is being used or what kind of product is being manufactured.

Witness our quick-rusting sheets, our brittle steel, our deep drawing stock that won't draw, our hard cast iron, brittle malleable, and dirty porous castings, and you have a survey of the penalty for urging your scrap on the producer.

Rust is an oxide of iron, and it is finely divided. During the melting process this rust or oxide enters the metal and becomes emulsified. And no amount of fluxes, deoxidizers, or other cleansing agents will get it out. I believe suspended oxides in metal are causing more trouble today in the iron and steel industry than any other one thing. The use of such material is directly at variance with all the sound principles of metallurgy. How long the manufacturers will use this material and how long the consumer will continue to receive such metal is a problem. But the light is breaking and the day of reckoning for the iron and steel manufacturers who attempt to melt up nothing but junk, is close at hand.

It would appear at first sight that cold metal is distinctly a problem of the melting department, but it effects the molding department so strongly that the molder must take it into consideration. It is a well known fact that the moment molten metal strikes the mold a large volume of gas is generated.

This gas is formed from the decomposition of binding materials, but most of it comes from the water that is in the mold.

If such gas is not allowed free exit, it is going to be trapped in the metal, and the colder the metal is the more quickly it will set, and the more likely it is that the gas will be trapped under a skin of frozen metal.

How many times does a foundry turn out what is apparently a perfect casting only to find it rejected in the machine shop just as soon as the first cut is taken from the cope side. The gas trying to escape has been trapped just below the surface because the metal has set too quickly to allow the gas to get away; this is a very common defect in green-sand molding; hence the necessity when attempting to make green-sand work, of having the metal very hot and fluid and venting not only the cope but the drag, and making sure that the vents in the cores are wide open.

The Sins of the Cover Core

An interesting sidelight in connection with this discussion is the question of oil-sand cover cores. It is a very common occurrence to find a casting made under a thick, hard oil sand cover core, with absolutely no provision for the escape of gas. The foundryman struggles along and probably gets two out of ten castings, whereas if he would merely puncture the cover core with three or four pop heads and let the gas out, the probabilities are that all of the castings would come good. There is not a week that passes but that the writer is not called upon to remedy this mistake in some foundry, for it is remarkable how frequently this mistake is made.

The question of shrink heads or risers is one that is given too little consideration in the foundry. A head to be of any value, must be large enough in cross section so the heap sand will not freeze it up too quickly. It is well to remember that probably not over 30 per cent of the cross section of a head is available for feeding and this statement applies with more than ordinary force to the neck of the feeder; it is folly to make a great big head and then neck it down so narrow that the neck freezes almost instantly, and it is equally futile to

expect a head to feed if it is not placed squarely upon the casting. But how often does one find a head with a neck say 2½ or 3 inches in diameter about one-fourth of which is attached to the casting and the rest is wandering off in space.

The common practice of taking an old splintered block of wood, sticking it into the pattern with a nail, and attempting to make an efficient head is the falsest of false economy. A foundry should have a stock of standard heads carefully made in the pattern shop and fitted with dowel pins so that they can be set squarely upon the pattern with little danger of being misplaced.

There is a tendency among foundrymen of the present day to skimp on heads. They love to talk about their very low sprue returns but they neglect to state that the welder works overtime every night. Molten metal will shrink as it cools and that shrinkage must be taken up either by overhead feeding or internal chilling, and when a foundryman tries to tell you that his castings are sound without any kind of feeding, that man is trying to change the laws of nature, and personally I cannot see how he is going to get away with it.

Another big question in the foundry today is the matter of water in its various forms. There is probably no other one factor with the possible exception of oxygen, that has so much to do with the success or failure of a foundry as water. Consider a moment some of the troubles directly traceable to the old H_2O. In the cupola for instance, we have the well known rubber bottom from wet bottom sand; we have cold metal and slow melting from wet coke, wet iron, and moisture-laden air. In the converter we have wild heats, cold metal and cut linings, from the lining being too wet. In the foundry we have the well known pin holes from the metal boiling on the surface of a wet mold; we have entrapped gas, and dirt, because too much water in the facing and heap sand has frozen the metal prematurely, and securely trapped the gas and dirt within.

Hydraulic Castings and Green Sand Molds

A casting may look sound, but millions of tiny bubbles of exploding steam have made it porous so that it will not stand

up under gas or water pressure. All over the country foundries are making hydraulic and ammonia castings by the green-sand method; and they are stoutly claiming the fact that they are getting away with it. Careful investigation, however, will prove that the consumer is kept busy closing up porosities and that every so often a truck load of defective castings are brought back to the foundry and are carefully smuggled in the back door, so too many people won't see them. It is possible to make hydraulic castings in green sand molds, but it is not possible to make them day in and day out and be fairly certain that they are all sound. It is almost an impossibility to control the water in the green sand mold; and water suddenly converted into steam has a habit of exploding in the most unforseen places and in the most peculiar ways. As a general rule, a hydraulic or gas casting should be made in a thoroughly baked mold, and if proper materials are used, and the melting is carefully done and the mold is kept clean, there is no trick in turning out acceptable hydraulic castings.

There is one more item in the molding department that deserves attention and that is the proper method of pouring. The scrap pile receives a great many contributions because of the carelessness or incompetency of the man at the ladle. Every ladle of metal should be held for a minute or two to allow the slag and other impurities to come to the surface. Stopping to allow the metal to clear itself may seem like a waste of time to the modern production hog, but if the gentleman will stand by a ladle and watch the various impurities float up to the surface he will understand why it pays to give the metal time to clear. In the end more good castings will accrue from such practice, and in the final analysis real production will be increased. Metal going into a sand mold should be poured evenly and carefully and under no consideration should hot metal be poured at high pressure directly over a large flat area of sand. Cuts and scabs and snakes are too often the result of fast, furious pouring. It is far better when dealing with a casting having a large flat surface, to cut back-up gates and break the force of the stream of metal rather than

resort to a mass of finishing nails, a lot of swabbing and other dodges to prevent the facing from cutting.

Another exceedingly common error is the practice of pouring metal directly up against a core at right angles to it. If it is possible to allow the metal to slide parallel to the core, there will be far less cutting and much less dirt.

It is obviously impossible for any one man or group of men to enumerate, much less describe, the many apparent defects and troubles that exist in a foundry. If the foundryman will carefully study and examine the defective castings, if he will try to trace out his problems from cause to effect rather than trust to dumb luck, he will find, as stated before, that the real fundamental troubles in the foundry are comparatively few.

The value of a scrap pile lies in the fact that it offers a real course of instruction in foundry practice, and this paper has been written in an attempt to induce the foundryman to commune with his defectives, to study their peculiarities, to grasp the principles of casting in their broadest sense, to realize his responsibility to the community, and finally, it is written with the hope that the foundryman will earnestly strive to manufacture sound castings, rather than alibis and fictitious production sheets.

Discussion

MR. ROBERT J. ANDERSON.—At the present time, foundries are in need of inquiry as to the reasons for scrap losses and wasters in the production of castings, and no preventative measures can be taken until the causes for defects are known. Every progressive foundryman should inspect his daily production with a view to determining the reasons for defects. The suggestion offered in the paper that an experimental molder should be employed is sound. Although Mr. Traphagen has

not given any figures for scrap losses, it is a well known fact that these are often high in many foundries.

The author complains of the work done by scientific men in connection with foundry practice and claims that their contributions to the literature are of little value to foundrymen. The writer entertains considerable doubt that the literature of the foundry is any worse than that of any other industry, and is compelled to conclude that the fault does not lie entirely with the scientific men. It seems to me that it is exceedingly dangerous to belittle the work of scientific men in general. As a matter of actual fact, with the exception of the present paper by Mr. Traphagen, and a few other papers and some text books, I have never been able to find a frank discussion of the foundryman's troubles written by foundrymen. This is an opportune time for foundrymen to lay all the cards on the table and come to the fore with a frank discussion of their difficulties.

Relation of Gases to Casting Practice

Mr. Traphagen's remarks regarding gas evolution when liquid metal is poured into a sand mold are interesting. The relation of gases in metals and alloys to casting practice is one that has been rather neglected. In casting, gases are derived from two sources; those evolved from the metal, and those set free by the mold and possibly the cores. Liquid metal cannot remain in an impervious mold because the gases evolved must find an outlet. In the case of an impervious mold, the gases would find a path to freedom by throwing the metal through any possible outlet, and here there would be a kick-back through a runner or ejection through a riser. The gases evolved on pouring liquid metal into a sand mold must be drawn through the sand, and it is usually necessary to augment the porosity of the sand by venting. Blowholes and sponginess in castings may be due to gases dissolved in liquid metals which are liberated on final freezing. These defects can also result from gases given off from the mold and cores on pouring. Chill blows and core blows are defects which every foundryman is familiar with, and they can be overcome by proper precautions. With particular regard to gases in metals, liquid metals dissolve increas-

ing quantities of gas with rising temperatures. This is a departure from the law of Henry, for aqueous solutions dissolve less gas with increasing temperatures. Hence the higher any metal or alloy is heated before casting, the more gas will be dissolved. These gas-metal solutions readily remain supersaturated, and consequently an overheated melt will usually contain more gas at the moment of pouring than one heated not so high. If the dissolved gas is largely given off during the freezing range, and this appears to be the case, then castings poured from overheated charges will be more porous than those poured from charges heated to the correct temperature. Probably the greatest variable in iron and steel casting practice, with the exception of the human element, is the casting temperature.

Troubles Traced to Molding Practice

In the daily inspection of castings, it is possible to enumerate the defects which lead to rejection, determine the causes, and make corrections. Defects in castings may be grouped roughly into three classes, namely those due to metallurgy, those due to molding, and miscellaneous. Mr. Traphagen's statement that 90 per cent of the troubles can be traced to the molding department accords with the writer's experience. Many of the defects traceable to the molding department are due to carelessness, and this is particularly true under fast production methods. Laxity in mold inspection is a prolific cause of defects in the resultant castings. Misplaced cores, core shifts, cores left out, chills left out, dirty cores, broken cores, poor ramming, misruns, run-outs, etc., can largely be avoided by proper supervision. Many of the defects in castings can be placed in the avoidable class at once. Some defects are due to the method of molding, the gating, and the position, and size of risers. These cannot be remedied unless by changing the molding, and this is where Mr. Traphagen's experimental molder will be extremely useful.

Concrete Foundry Molding Floors

By Hutton H. Haley, New York

A foundry, no matter what its kind, type or size, is not a solid, compact, producing institution in the same sense as those branches of the metal-working art with which it is so closely associated. Almost every part of a machine shop, for instance, may be operated with clock-like regularity; every move, operation, cost or loss may be closely tabulated and predetermined if necessary. Hence the machine shop, which usually has an intimate connection with the foundry, is tangible in its operations. The foundry, however, may be likened to the stomach into which raw materials are taken, broken down, assimilated and a new product generated with varying degrees of wastage. The foundry is constantly affected by wide ranges of fluctuations, caused by innumerable unpreventable conditions and contingencies, therefore it is recognized by those well versed in its practices to be perhaps the most intangible, misrepresented and least understood of all our great industries.

In a foundry it must be understood that the basis of production is and probably always of necessity will be more or less destructive, crude, dirty and disagreeable compared with other metal-working processes. The fluctuating common-labor element will always play an important part as it cannot be entirely supplanted by mechanical devices. This being the case, it would seem wise to anticipate the most agreeable conditions possible and to provide every reasonable facility for light, air, cleanliness, neatness and order. The foundry is too often pictured as a place where filth, darkness, heat and disorder abound and very often all of these disagreeable conditions exist. However, anyone who has visited any number of our most up-to-date foundries will readily agree the reverse may be true. No floor expanse may be viewed with as much pride and satisfaction as a business-like foundry, shipshape and ready for work shortly before seven o'clock in the morning or just before heat time, with its floor checkered with thousands of orderly molds. Every profit-mak-

ing foundry should be kept in "fighting trim" and one of the most, if not the most important contributions to such a condition, is a satisfactory floor.

Five Basic Features

The five basic mechanical features of a successful foundry may be analyzed as follows: (a) Good, firm, level and clean floors; (b) well prepared molding, facing and core sands; (c) the best of pattern and flask equipment; (d) efficient mechanical molding devices and equipment; and (e) correctly proportioned casting metals. Each plays its part, has its function to perform and contributes to the sum-total result.

There exists in the minds of many foundrymen a misconception regarding the practical use of concrete for foundry molding floors, although it is generally agreed among the users of this material that it surpasses other forms of pavement. No pavement is perfect, yet all have merit, concrete seeming to possess the fewest deficiencies.

The four most common objections to the use of concrete may be summed up as follows: First, spattering or "popping" of molten iron spilled from the ladles may occur where concrete floors are used. This is caused from an almost instantaneous generation of steam when the molten metal comes in contact with the concrete, which is more or less moist at all times. An explosion follows and particles of red-hot metal are apt to fly 5 or 6 feet in all directions, resulting in painful burns. Occasionally such an accident has been responsible for loss of eyesight. This complaint may be entirely overcome by properly finishing the surface of the concrete, as described later.

The second objection lies in the crumbling and breaking down of concrete floors due to general weakness in design, faulty aggregate composition, insufficient curing when green and disintegration from violent expansion and contraction caused from the piling of very hot castings on the concrete floor after a shake-out. All these complaints may be automatically corrected in newly laid floors if the specifications and directions given in this paper are followed.

The third objection, of which less is heard, is the likelihood of tripping and falling over small iron balls of iron or shot,

formed from ladle spillage. This objection may be overcome by properly roughening the wearing surface of the floor.

The fourth objection to concrete for molding floors is found in the somewhat exaggerated claim that molders voice discomfort while working on it. Any solid pavement permits a pounding shock, as we walk over it. This is transmitted all through the lower extremities of the body, and results in minor physical injury, producing slight leg and hip fatigue and dull pains or soreness in the instep and leg muscles. Usually it is from molders who are unaccustomed to working on concrete floors that the complaints come, and then only for a short period until their muscles harden. We are all of us accustomed to pavements, and granting as we must, that the result is not entirely satisfactory in this one physical sense, yet we find their combined benefits eclipse this one disadvantage, and so it is or should be in the foundry. None of us would consider dirt walks or streets, nor would a foundryman who has experienced the results from a good concrete floor return to clay or sand floors. It would perhaps be of benefit and but little trouble and expense, to make a die and cut out full soles from a cheap grade of rubber, attaching them as often as required to the molders' shoes.

Advantages of Concrete Floors

A concrete floor has the advantage of presenting a clean and dry surface thereby preventing pneumonia and chronic rheumatism, especially during the winter season, when sand and clay floors are apt to be continually damp, cold and frequently full of frost during the forenoon. There are not a few such floors, built over boggy land, which have induced a high mortality rate.

The results to be gained from paved foundry floors are genuinely worth while. For instance a foundry in Toledo found after careful time studies that it would be possible to reduce the casting losses and improve the quality of the output by the installation of a pavement on which the molds would rest firmly and evenly. A brick floor was installed and the result was approximately a 5 per cent gain, divided between reduced losses and increased production. Level molds are an advantage

not to be lightly overlooked in these days of intricately cored, difficult, thin-walled, delicately sectioned castings. Also such a pavement provides a mechanical guarantee and eliminates the human element which must otherwise be depended upon to level each mold set down on the usual irregular sand or clay floor.

Brick pavement is not recommended, as its structure deteriorates much faster than concrete. Furthermore, it breaks down on the edges, forming holes, and is disagreeable to shovel on. A Belgian sawed block, set on concrete, makes a splendid floor but is very expensive.

In a general way it may be said that the use of concrete for floors, pits, foundation walls, etc., is not thoroughly understood by the average contractor. The unsatisfactory results so frequently experienced from concrete floors, leaky pits, cracked masonry, etc., arises from the ignorance of those having the preparation, laying and curing in hand, or in attempting to hasten the completion and use of the structure.

Prepared pavings, such as brick, wood block, etc., are scientifically manufactured to set standards and identical results, under average conditions, may be anticipated and guaranteed from Maine to California. With concrete, the conditions are different. The Portland cement itself is standard, but it forms only a small percentage of the total aggregate which is composed of rock, gravel, sand and water. Each plays an important part in the finished result. Being bulky, the coarse aggregates must be secured locally, each varying, as is to be expected, in quality, structure, etc., according to origin. The preparation of the mixture, a highly important and little understood factor, is too often supervised in a careless manner or by a person who possesses experimental ideas of his own, and in consequence the result is apt to be unsatisfactory.

A Specification for Molding Floors

The data given in the following are based upon practical experience rather than theory, and it is hoped this paper will be of benefit and may bring forth voluntary reports from foundrymen and foundry engineers who may see fit to adopt its suggestions.

The first thing to consider is a specification for concrete molding floors. This specification is as follows:

(A concrete mixture is composed of three prime elements: Portland cement, fine aggregate and coarse aggregate. The proportions are always referred to in the order given above, as 1:2:3 mix, which is composed of one (1) sack of Portland cement, two (2) cubic feet of fine aggregate and three (3) cubic feet of coarse aggregate. A cubic yard of concrete in place shall contain not less than six and eight-tenths (6.8) cubic feet of Portland cement.)

Subbase.—Concrete floors laid over ground having soft spots or on boggy ground should in the first instance have the soft spots dug out and filled, and in the latter instance the entire ground covered or filled with from 3 inches to 5 inches of gravel, crushed slag or steam coal cinder free from particles of unburned coal, soaked thoroughly, tamped and rolled into an unyielding mass. It is important this subbase be well soaked immediately prior to placing concrete thereon.

Thickness.—With proper subbase a 3-inch concrete floor will suffice for light and medium heavy work. For heavier work and over boggy and sloppy land a 4-inch floor is recommended. For heavy-work center bay floors the thickness should be increased to 5 inches. A foundry melting floor should always be one course, that is, laid solid to the thickness desired in one operation without a second finish coat.

Fine Aggregate.—Fine aggregate shall consist of natural clean sand or screenings from hard, tough rock or gravel which, when dry, will pass a No. 4 wire mesh screen.

Coarse Aggregate.—This shall consist of clean, hard, tough crushed rock or pebbles graded to size and shall contain no soft, flat or elongated particles. The size shall range from three-quarters (¾") inch maximum for a 4-inch or 5-inch floor down to one-half (½") inch maximum for a 3-inch floor. Limestone and shale should be avoided if possible as the structure of either is none too good. New England trap rock surpasses all other stone for coarse aggregate and where the freight rate is not prohibitive its use is recommended.

Coarse Iron Aggregate.—This aggregate should be composed of cast-iron borings, preferably from cylinder, piston or similar iron. These borings contribute a bonding strength to the concrete and form avenues for the absorption and escape of excessive heat from hot metal spillage and the piling of hot castings on the floor, thereby preventing undue expansion and contraction of the concrete and consequent deterioration. This iron aggregate may be extended all through the entire molding floor with very beneficial results if desired, in which even only 10 per cent (10%) by volume of the total concrete mix need be borings, except for the gangway where the

borings should be increased to 2:1:3 of borings, or a 1:1:1 mixture plus 1 of borings. In the event only the gangway aggregate is to be treated with borings, it should be amply deep to provide for laying hot castings thereon.

Machine Mixing.—The ingredients of the concrete floor shall be mixed to an even consistency in a mechanical batch mixer of improved design and mixing shall continue for at least one minute, preferably somewhat longer, after all the materials are in the drum. Raw materials shall not be permitted to enter the drum until all the material of the preceding batch has been discharged. It is impossible to secure an even, thorough, homogeneous mix by hand methods, which should never be attempted.

Retempering.—Retempering of unused concrete which has partly hardened; that is, remixing with or without additional materials or water, shall not be permitted under any circumstances. Such material shall be discarded.

Water.—Use the smallest quantity of water which will produce a workable mix. It is highly important that the proportion of water in the concrete mix be too little rather than too much. A normal plastic workable 1:2:3 mix should present what is termed a quaky state, to secure which the average minimum water per sack of cement used should run five and one-half (5½) gallons to not more than six (6) gallons. The function of water in concrete is two-fold: (1) To supply the water necessary for hydration of the cement, (2) and for the purpose of producing a plastic mix. The influence of the water-ratio on the strength of concrete may be readily understood when by way of illustration it may be said that one pint more water than necessary to produce a plastic concrete in a 1:2:3 mix, for example, reduces the strength to the same extent as though 2 to 3 pounds of Portland cement were omitted from a one-bag batch. The reason that a rich cement mixture gives higher strength than a lean one is not that more cement is used, but because the concrete can be and usually is mixed with a lower water ratio in the case of the richer mixture. In general it will not be feasible to use concrete of a consistency which will give the maximum strength, since it is somewhat too stiff for satisfactory working. Hence some sacrifice of strength is necessary in order to secure a workable mix. It is urged that the water content here specified be not exceeded for foundry floors.

Placing.—Before placing concrete thereon the subbase should be thoroughly soaked. After mixing the concrete shall be handled rapidly and in successive batches, within thirty (30) minutes after water has been added to the dry materials, and shall be deposited in a continuous operation completing (when laid in slab form) individual sections to the required length and depth without stoppage for any cause. Any excess of concrete over that needed to complete a

section, at the stoppage of work, shall be discarded and not used under any circumstances. In no case shall concrete be deposited upon a frozen subbase nor shall a completed green floor be exposed to freezing weather without tarpaulin, canvass or some other such protection spread over it.

Forms.—All wood forms shall be thoroughly cleansed of old mortar and dirt and wetted. Metal forms should be coated with oil, soft soap or whitewash before depositing concrete against them. It is undoubtedly a mistake to use the individual slab practice, with expansion joints for a molding floor. The edges of slabs whether rounded or square will in time break down. Once concrete suffers a bad hole or crack it deteriorates at that point in a manner similar to a tooth with perforated enamel.

Expansion Joints.—It is recommended that no expansion joints be provided in the finished floor, the concrete in forms being struck off level with sharp edges; the forms removed when the concrete has hardened to the point where there is no danger of a slump, and the sides so exposed well roughened in order that when the concrete in the adjacent slab is laid thereto it will thoroughly knit into the roughened surface provided. To assist in perfecting a knit it is well to brush the roughened surfaces with a mixture of neat cement grout of a creamy consistency just previous to placing the fresh concrete against the side surface of the preceding slab which has been so prepared. Grout should not be used after it is 45 minutes old. Special pains should be taken to eradicate any surface seams, crevices or edges as the floor is bound to be weak and subject to disintegration at such points.

Finishing.—When finishing a concrete molding floor to be terminated at the gangway wherein wood block are to be installed, the edge of floor should be finished off with a light angle iron, the web of which should equal the thickness of the floor, pressed or embedded firmly into the concrete as a curbing. In a strictly slab floor, not reinforced, the limit is 100 square feet. In a continuous foundry floor where the forms are used rather as a convenience while placing the concrete and to provide for the immediate contraction during setting, the slabs may be increased into whole sections sized conveniently, it only being necessary to complete each section through continuous operations without any stoppage of work for any cause.

The finishing and curing of a concrete molding floor is of prime importance. After placing the concrete it should be struck off with a sweep or strike-board to the established grade of the forms. Further working should be avoided; the wood float or trowel being absolutely taboo. The surface *must not under any circumstances be troweled or finished smooth.* When the floor has set to a consistency of stiff putty and will show no slump, a long-handled hand roller,

having parallel or checkered corrugations three-eighths ($\frac{3}{8}$") inch deep and of sufficient weight to make full indentations in the concrete surface should be passed over the floor and gangways. These indentations will hold sufficient sand to prevent popping of molten iron when spilled on the surface of a concrete floor so finished, even though the floor be swept. Furthermore, the indentations provide nests to collect and hold the shot iron which are apt to throw workmen.

Curing.—Perhaps the greatest cause for the failure of concrete floors may be traced to the entire lack of or insufficient curing of newly laid green material. All forms of concrete show great increases in strength under favorable curing conditions as compared with specimens which have been allowed to air dry. In arid regions and during warm weather freshly laid concrete is exposed from the moment it is laid to rapid evaporation of the mixing water. Therefore the chemical action in process during "setting" is retarded and a portion only of the strength is secured. Concrete floors of any character should be covered with sand, shavings, saw-dust, or some such material as soon as the floor has set to a consistency which will permit the placing of such a topping, which in turn should be soaked twice daily. A 21 to 30-day storage is apparently about the ideal length for the best curing results, as by the expiration of these time limits the strength and wearing qualities will have increased some 150 to 200 per cent over the original strength of the same floor allowed to air dry. It is urged that every concrete floor be cured at least 10 days, the very minimum being three days.

The use to date of prepared wood-block for molding floor gangways, under the cupola spouts and on charging platforms has met with splendid success. The spillage of iron on wood blocks merely chars it slightly, molding sand filling in the char holes and preventing further burning.

Aside from the first cost of wood blocks, which must themselves be laid on a concrete foundation, this form of pavement for a molding floor seems quite ideal except perhaps in foundries running string sand floors, such as stove shops, where the molder's shovel comes in contact with the floor continually. It is thought the slight projections of the corners of the blocks may present a roughened surface to the shovel and annoy the molder.

In conclusion, the author wishes to acknowledge his indebtedness to Prof. Duff Abrahams, Lewis Institute, Chicago, and the Portland Cement association.

Discussion—Molding Floors

Mr. Lambert T. Ericson.—It is generally conceded that the first and most important step to take in cleaning up and modernizing a foundry consists in building a smooth and durable floor and establishing a permanent level to work upon.

The selection of the materials to use on the floor is an important matter. Mr. Haley has carefully pointed out that it is necessary to take the most careful precautions in the proper selection and grading of the materials in the concrete, to add just enough and not too much water and to take plenty of time to let the concrete cure; that neglect in any of these details may result in failure; that the only material in the aggregate which is standard in all parts of the country is the portland cement and consequently, the work must be done under the supervision of an expert who thoroughly understands concrete My own experience is that very few concrete experts agree as to the best specifications for the mixture. A great many disagree with Mr. Haley on the point of the amount of water to use on account of the physical impossibility of properly placing such a dry mixture. Consequently specifications will not be followed to the letter, if the work is left to a local expert.

Mr. Haley recommends three to four weeks curing of the cement and urges a minimum of 10 days. This feature of delay makes it almost impossible for the operator to consider the construction of concrete floors in any except new or unused buildings.

A wearing surface of creosoted wood blocks over a concrete sub-base is almost indestructible under traffic. The blocks are equally adaptable to molding floors and in the truck ways and impact does not cause the wood block to disintegrate. They are not affected by temperature changes and are warm under feet in winter and cool in summer and under the heat of a foundry. Changes and repairs are easily and economically made. Wood block floors are popular with the workmen, im-

prove their health, decrease the sickness and consequently the amount of absence from work and decrease the accidents around the plant. Properly constructed they are waterproof and dry and, as Mr. Haley has stated, they are impervious to spillage of iron, since they merely char slightly, molding sand filling the char holes and preventing further burning.

Creosoted wood blocks lend themselves with equal facility to the construction of new floors, the resurfacing of old concrete floors, or the resurfacing of concrete floor slabs, of reinforced concrete buildings. Under stress of necessity, wood blocks can be installed within 48 hours of the time of the construction of the concrete sub-base and the floor is available immediately thereafter.

Wood block floors recently have been installed in a large motor foundry in Flint, Mich., without holding up production in any way. The foundry is located on the second floor of a reinforced concrete building. The coreroom and core ovens are in one end and the foundry in the other end. The floor area is approximately 108,000 square feet. The original wearing surface of concrete was surfaced with a dry cement cushion, upon which wood blocks 2½ inches thick were installed, the work being done in sections entirely at night, with company forces, under the supervision of the wood block manufacturers' service department.

The installation of the blocks is comparatively simple and the average foreman can take care of the work very easily, after having secured a little instruction. Wood block floor construction requires expert supervision principally for the instruction of the local foreman.

Wood blocks must be properly manufactured and the floors constructed under proper specifications. They require a solid, immovable base, preferably concrete. The blocks must be laid with tight joints, filled with coal tar which, to make them waterproof and to make them stand up under the wear and tear. The objection mentioned of the possible roughness causing the molder's shovel to come in contact with slight projections at the corners of the blocks, need not receive serious consideration. Proper construction methods will insure a smooth floor.

Audible Signals in Foundries

By Vladimir Karapetoff, Ithaca, N. Y.

The following types of audible signals are actually in use in various foundries: Electric horns similar to those used on automobiles, Fig. 1; air or steam whistles, sometimes electrically operated from a distance; and bells and gongs, either single stroke or continuous. In an efficient up-to-date foundry such audible signals should be used for at least the following five purposes:

1—For calling any important employe to the nearest telephone no matter where he may be; this presupposes a prearranged code and some simple device for sounding calls.

2—As extensions to telephone bells in noisy places; a foreman may not hear his telephone bell when away from his desk, but he would most likely hear one or more loud horns or shrill whistles mounted in the shop.

3—For purely local needs and signals, for example, to indicate the beginning and the ending of pouring, to call a craneman or an electrician to some prearranged place, etc.

4—As warning signals of danger on cranes, hoists, locomotives and trucks, especially when a ladle with molten metal is in motion.

5—For sounding fire-alarms.

Imagine yourself sitting as an observer in the molding and pouring department of a large foundry properly equipped with audible signals. You will soon hear one or more electric horns sounding a code number, for example, one, one and two (1-1-2). This may mean that the superintendent is wanted in his office, but that there is no particular hurry about it. Had the call been one, two, two (1-2-2), it would have meant a hurry call and you probably would have seen the superintendent running to the nearest telephone.

Soon afterward you may hear two long blasts of an air whistle, signifying that everything is ready for pouring in the north aisle. A few minutes later it might be followed by a continuous ringing of a bell to warn the workers that a big ladle full of molten metal is being carried by the crane.

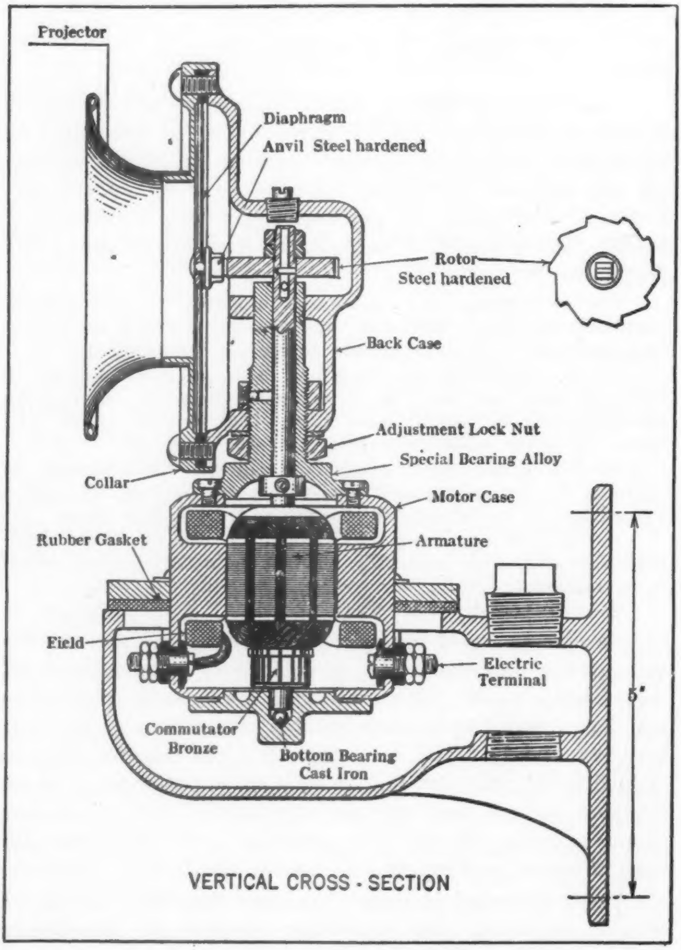

FIG. 1—CROSS-SECTION OF AN ELECTRIC HORN

A vertical shaft motor drives a toothed wheel which strikes an anvil fastened to the center of the sounding diaphragm

To make the picture complete, let us imagine that after a time you hear a single-stroke gong sounding number four, three (4-3). This may designate a fire in the pattern shop, or may simply be an agreed call for a fire-drill.

For contrast, let us go to an out-of-date, shabby, primitive foundry, which is still running on the "chance and luck" principle, found to be satisfactory by our forefathers. In those days a molder received a dollar or two for a 12-hour day, and the output was measured in pounds where it is now stated in hundreds of tons. Two or three office boys are running all over the works trying in vain to locate the superintendent who is needed in the office to help on a very important quotation. When he is finally located, it is too late to take care of this matter in the proper way. A millwright is needed in a hurry to take care of a hot bearing on a rush job, and nobody knows where he is. He happens to be attending to an unimportant job in a dark pit, and is blissfully ignorant of the fact that he is urgently needed elsewhere.

Actual experience not only in foundries but in all kinds of industrial establishments has demonstrated the importance of audible signals in promoting both the efficiency and the safety of operations. Horns, bells and whistles are simple pieces of apparatus available on the market. Their cost is trifling in comparison with their useful service, and any far-sighted foundry manager can readily see the great advantage of equipping his works with acoustic signals, once the matter has been properly brought to his attention.

A Code-Calling Device

Fig. 2 shows a simple device for sounding simultaneously any desired number of horns, whistles and gongs scattered throughout the works, and for calling various persons according to a prearranged code. The electrical connections are shown in Fig. 3. The device consists essentially of a number of toothed wheels which close and open an electric circuit in a certain sequence. These wheels are mounted on a shaft operated by a clock spring. A drum is provided with a combination of 40 simple arrangements of contacts, such as 1-2, 1-3, 2-3, 1-1-2, etc. The horns are connected to an

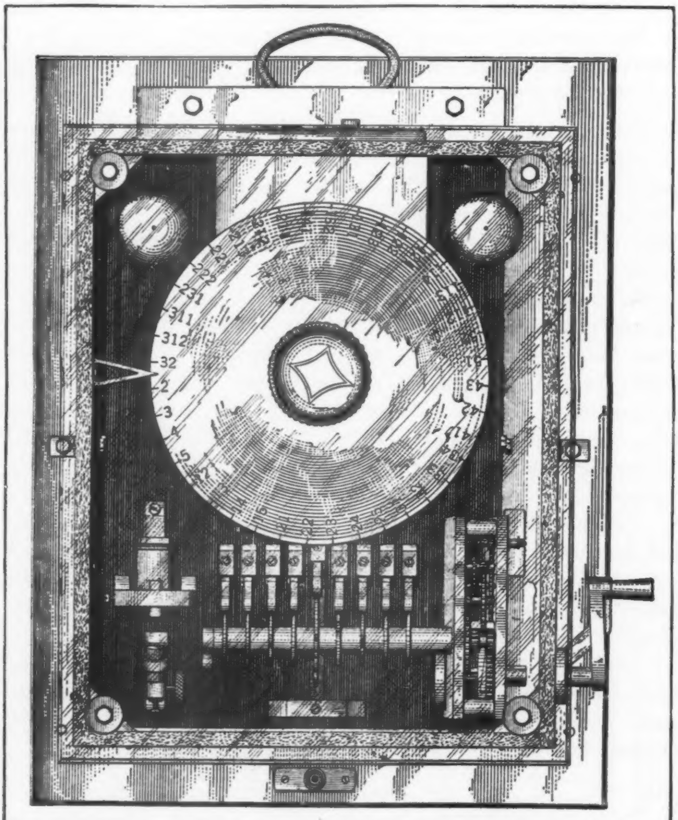

FIG. 2—A CODE CALLING MECHANISM
The operator sets a code number and pulls on a handle. This closes the electric circuit the required number of times, and makes the horns and the bells sound throughout the plant

available 110 or 220-volt circuit, either direct or alternating current, while only a small current from a few dry cells is used in the central instrument. This current closes a relay which operates the power circuit between two contacts especially designed for frequent opening.

When it is desired to call some person, the code handle *A* is set on the number assigned to that person, and the

operating handle *B* is turned by one-half a revolution. This is all the operator has to do. The contact shaft is set in motion by the spring and the circuit is closed a certain number of times in accordance with the position of the code drum. Every time the battery circuit is closed the relay closes the power circuit and operates, all the horns, whistles, gongs or lamps connected to it. Having sounded the complete call three times the handle *B* returns to its original position and the mechanism is ready for the next call.

In most cases it is considered sufficient to sound the call number three times. The first time the person may not be sure whose call it is, the second time he counts the sounds and the third time he checks himself. For exceptional purposes, the call may be sounded more or less than three times or even continuously until stopped.

The operation of the code-calling mechanism is usually entrusted to the telephone operator, where a private branch exchange is available. If the manager needs Mr. Jones and fails to reach him by telephone at his desk, he tells the telephone operator to sound his call number. Mr. Jones may be anywhere in the works, but as soon as he hears his number he comes to the nearest telephone and reports to the telephone operator who immediately connects him with the manager's telephone. Special cases have arisen in which the operation of the code-calling instrument had to be entrusted to a clerk in the superintendent's or production manager's office, in order to prevent office boys, clerks, etc., from disturbing important members of the staff on trifling occasions. The operator of the calling device is supposed to inquire about the nature of the business before starting the call.

When the number of persons to be called is not great, say 10 or 12, it is sometimes convenient to assign two or three different numbers to the same person. These three numbers may mean respectively: (1) "Call me on the phone immediately;" (2) "Call me when through with the present engagement;" (3) "Come to the manager's office."

The particular rules for the use of the code-calling equipment differ from factory to factory in accordance with

the local conditions, and may be modified from time to time as actual experience indicates.

Some care must be exercised in the selection of the type of sound-producing signals and of the number of such devices in each department. A buzzer or a bell would not be heard near a tumbling barrel or a sand disintegrator; on the other hand, a powerful electric horn would be out of place in an office.. Each signal must be distinctly heard under the most intense noise possible in that department by a person most unfavorably situated with respect to the signal. At the same time it would be a mistake to use unnecessarily strong signals, which are liable to get on the workers' nerves.

The pitch of the signal (high or low voice) is another factor to be considered, and while no accurate experiments

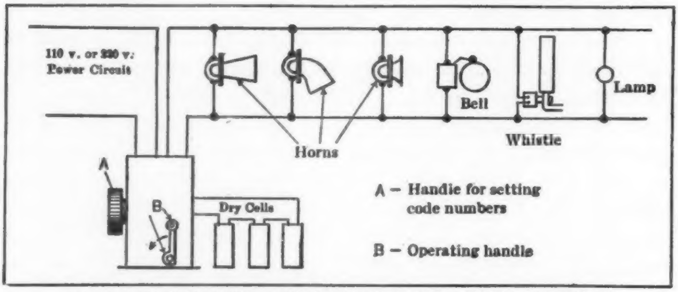

FIG. 3—THE ELECTRICAL CONNECTIONS FOR THE CALLING MECHANISM
A local battery closes a relay, which in turn closes the power circuit to which the audible devices are connected in parallel

are available, the selection should be governed by the principle of contrast. In a shop with a low-pitch rumbling and howling noise a shrill signal is more liable to be heard, and vice versa. Again, where the noise is of a discontinuous percussion type, like hammering or riveting, a horn with its steady sound would immediately attract attention. On the other hand, where the noise is continuous like that of a blower, a loud single-stroke bell might cut through the noise more readily.

Acoustic signals are so inexpensive that it is an easy matter to change them, or to change their position and number, should the first installation be not quite satisfactory.

Everyone knows that electric lamps sometimes have to be shifted in a shop until the desired illumination has been obtained. The advice of an acoustic specialist in particularly noisy shops may save some experimenting in this respect.

Musical sounds differ from one another in the following three respects: *In pitch,* high or low; *in intensity,* loud or soft; and *in quality* (timbre), such as brass, reed, string instruments, human voice, etc. Noise is a nonharmonic combination of such sounds, and can be analyzed into its components. These fundamentals of acoustics are now being applied to the solution of industrial problems, and the science of industrial acoustic engineering is rapidly growing, bringing with it increased economy and efficiency.

There are engineering concerns which specialize in acoustic signals and in intercommunication problems, just as other engineering concerns specialize in factory illumination, ventilation or sanitation. They have accumulated considerable experience in installing signals in noisy places and it would pay a foundry manager to get advantage of their advice in laying out a new code-calling system.

The following are the principal *sources of noise* in a fully equipped foundry:

Molding Department.—Vibrators for loosening sand from patterns, jar-ramming machines, cranes, trolleys, hissing of compressed air; noise of conveyors, trucks, wheelbarrows, etc.

Cleaning or Trimming Room.—Tumbling barrels, air chisels, pneumatic drills, grinding wheels, scrapers, band saws, conveyors, sand-blast machines, hissing of escaping air.

Sand Mixing Room.—Gears, chains, disintegrator hammers, magnetic separator for iron stays, and electric motors.

Melting Room.—Roar of blowers and of combustion (especially when burning oil); cranes and conveyors. Not very noisy.

Core Department.—Hammering, jar-ramming machines, escaping air, gas or oil furnaces, sand conveyor, a traveling crane, and trucks.

Welding Department.—Roar of the oil-burning furnaces for preheating defective castings; hissing of the oxyacetylene flames; handling, hammering and dragging of castings.

Discussion—Audible Signals

PROF. KARAPETOFF.—Loud speaking telephones are in use in some railroad stations, in offices and on warships, and those who have had experience, especially in railway stations, know that sometimes it takes a good deal of imagination to know just where the train is going. Undoubtedly loud speaking telephones find their place where there are no loud noises; but in a shop, where it is difficult to even understand each other without shouting, I doubt very much if, at the present stage of development, a loud speaking telephone would be feasible at all, not to speak of its added expense. The only advantage that a loud speaking telephone might have over code calling would be in conveying a more definite message. Such messages are readily taken care of by a more elaborate code, without the necessity of listening as closely as one would have to listen to a human voice. One of such combinations might mean "Come to the telephone when through with present engagement." This would do away with the objection that a busy executive may be unnecessarily interrupted by code calls. Such an extended code answers any possible objection to code calling. Of course we all hope that the day will come when telephones will be either loud or else everyone can carry a wireless receiver about him and hear conversations by means of electric waves, but at the present stage of the development, I do not believe that is feasible. In offices loud speaking telephones are doing splendid service and I can recommend them.

MR. TOPPATE.—I would like to know if the professor has had any experience in using colored lights?

PROF. KARAPETOFF.—Colored lights are good in some places and I have seen them in use in some department stores where the floor walker can readily see them, and where audible signals may be objectionable to the customers. I am not at all opposed to colored lights or to any system of signals whatever. Any system of signals has to be properly designed in application to the problem on hand, designed by a specialist who understands all kinds of signals and who knows the local conditions.

The Testing of Clays for Foundry Uses

By Homer F. Staley, Washington, D. C.

The clays in common use in foundries are all plastic fire clays, that is, soft clays with comparatively high melting, or softening, points. However, plastic fire clays may be divided into eight classes or varieties. The first division is into clays of low and high plasticity. Clays in the first division are usually sandy, slake rapidly in water and have low bonding power when wet, while those in the latter are commonly fat and sticky, contain little sand, slake slowly and have high bonding power when wet. Each of these divisions may be subdivided into vitrifying clays, that is, clays that burn hard and dense at temperatures below 1200 degrees Cent. (2200 degrees Fahr.) and nonvitrifying clays, which do not burn hard and dense until temperatures above 1200 degrees Cent. are reached. Each of these subdivisions may be divided into two classes, first, refractory clays which soften at temperatures above 1550 degrees Cent. (2820 degrees Fahr.) and second, nonrefractory clays which soften at temperatures below that point. The relations of these classes of clays to each other can be seen in Table II.

Clays are used in foundries for three purposes: *First,* as mortar in the construction of fireclay brick linings for cupolas and furnaces; *second,* as daubing material for lining ladles and the repair of cupolas; *third,* as a binder in sand mixtures in making molds for steel castings. The requirements for satisfactory service in these three uses vary, and therefore the tests to be applied to determine the suitability of clays for each of these services should vary also. The object of this paper is to discuss the relation of the properties

of clays to the requirements of the service to be performed in different foundry operations and to describe tests that will determine the fitness of a particular clay for a given use.

High Temperature Mortars and Cements

The Importance of Proper Mortar Joints.—In general, foundrymen seem to fail to realize the importance of the use of the proper kind of mortar in furnace construction and lining of cupolas. They complacently follow the old custom of specifying that fire-clay brick shall be laid in the same clay that is used in making the brick. While brick manufacturers will furnish clay on these specifications, they cannot meet them literally. Fire-clay brick are made from a mixture of soft plastic fire clay and hard rock-like flint fire clay. The latter is very refractory but in the shape in which it is used in fire bricks is wholly unfit for use as mortar. Very rarely finely ground flint clay is mixed with plastic clay and sold as mortar material. The fire clay furnished for mortar is usually one of eight plastic varieties. In general it is less refractory than the fire brick of which it is one component. According to its properties and the conditions of service to be met, it may or may not be suitable for use as mortar in a given piece of furnace construction. It is perfectly possible that a more satisfactory mortar could be secured by the use of some other material.

Construction of Mortar Joints.—In the construction of fire brick parts of furnaces that are to be exposed to heat, the mortar joints should be kept as thin as possible, much thinner than the ordinary bricklayer is willing to make them. The essential difference between a bricklayer and a successful furnace builder is that the latter understands the necessity for thin mortar joints while the former cannot be made to realize it. It has been found in practice that when thick mortar joints are used in furnace building the structures fail

very quickly at the joints. In good furnace construction, therefore, fire clay is never used in the shape of thick mortar but only as a thin batter into which the brick are dipped immediately before being put into place. Bricks and shapes that are too irregular in form to permit the making of sufficiently tight walls in this manner with slight rubbing should not be used. If a trustworthy furnace builder is employed, the use of trowels for laying extremely thin joints may be permitted.

Furnaces should be, and generally are, so constructed that there is no necessity for the mortar to act to any marked degree as a binding material either before or after the furnace has been put into service. The function of the thin coating of clay batter is simply to fill small crevices between the brick. Of course, most raw clays and all hard-burned clays exert some bonding action, but this should not be considered as a factor in furnace construction or in selecting a clay for this work.

Table I—Classes of Plastic Fire Clays

Plastic fire clays	Plasticity low	Vitrifying	Refractory
			Nonrefractory
		Nonvitrifying	Refractory
			Nonrefractory
	Plasticity high	Vitrifying	Refractory
			Nonrefractory
		Nonvitrifying	Refractory
			Nonrefractory

Fineness Test of Raw Clay.—As far as properties in the raw state are concerned the only essential is that the clay shall work up with water to a thin fine-grained batter. This requirement is met by most plastic fire clays. A simple sieve test is sufficient to determine the suitability of a clay in this regard. All of the batter should pass readily through a 20-mesh sieve. If it does not do so, it should be put through a sieve of that mesh. The presence of coarse granules of clay prevents the making of a brick wall with thin tight joints. Of course the clay could be sieved dry through a 20-mesh sieve before the batter is made. Often, however,

this would result in the rejection of an unnecessarily large amount of material, for many coarse-grained clays break down into fine-grained material when they are mixed with water.

Tests of Burned Clay.—The tests of the action of heat on mortar material depend on the conditions to be met in service in the furnace. These conditions may be divided roughly into two classes. The first of these is that in which the fire brick construction is exposed only to excessive heat. The second class of conditions are those in which the brickwork must withstand not only the action of heat but also the solvent action of molten metals and slags or the abrasive action of strong blasts of flame or of moving charges. To meet the requirements of the first class of conditions, the only essential is that the clay be very refractory. The test to be applied in this case is a softening point test. To meet the other class of service conditions the clay must not only be refractory but also must burn under the prevailing furnace conditions to a hard, dense mass, suited to resist solvent and abrasive actions. In testing clays for this kind of service a softening point test should be made and also a determination of the temperature at which the mortar becomes vitrified, that is, hard and dense. To approximate furnace conditions these tests should be conducted while the material is subjected to load in the same manner that fire brick are now tested.* However, it is probably sufficiently accurate, and certainly more simple, to make vitrification and fusion tests on the material without the application of pressure.

Vitrification Test.—For foundry work it is probably satisfactory to define the vitrification point by noting the duration of heating and temperature necessary to render a small briquette of the material so hard that it is not possible to scratch it with the blade of a good pocket knife. This test should be conducted in a furnace in which the atmosphere is kept oxidizing or reducing according to the conditions that will prevail in the furnace to be built. If they are desired, more elaborate and accurate methods of determining vitrifi-

* Technologic Papers of the Bureau of Standards No. 7.

cation behavior may be found in the "Report of the Committee on Standards" of the American Ceramic society.

Softening Point Test with Use of Cones.—The softening point test may be determined either by the use of pyrometric cones or by the use of an optical pyrometer. The method with use of cones is as follows:*

(1) Preparation.—The clay sample, obtained with the same care and precision as for chemical analysis, shall be ground in an agate mortar to pass a standard 100-mesh sieve (0.0058-inch hole, 0.0042-inch wire). It shall then be made up with water to good working consistency.

(2) Test Pieces.—The test pieces shall be the size and shape of standard pyrometric cones—tetrahedra, 7mm along the edge of the base and 30 mm high. It is advisable that they be made in molds allowing of a somewhat greater height and cut to the required dimension when dry.

(3) Mounting.—The test pieces shall be mounted on plaques of refractory material, with the base embedded 1 mm in the plaque and the troweled face of the test piece (the numbered face of the standard cone) making a right angle with the plaque. Several test cones shall be arranged conveniently for the furnace used and alternated with standard Seger-Orton cones of successive numbers. The plaque may be of whatever shape best suits the furnace and may be biscuited to not above cone 010 before using, if desired.

(4) Heating.—The heating shall be done in a suitable furnace, preferably of the electric resistance type, at a rate not greater than 15 degrees Cent. per minute, nor greater than 10 degrees Cent. per minute after cone 1 is reached, or as nearly within these limits as possible.

If any other furnace such as a pot furnace is used, care should be taken that the flame does not strike directly against the cone or the cone plaque. Excessive reducing conditions should be avoided. With a gas or oil-fired furnace, the rate of heating cannot be controlled as readily as in an electric furnace but should be no greater than that required to cause the fusion of one cone in about three minutes.

(5) Softening Point.—The softening point shall be reported in standard cones and shall be that cone which corresponds in time of softening with the test piece. If the test piece softens later than one cone but earlier than the next standard cone, the softening point shall be reported thus: cone 31-32.

* Report of the Committee on Standards, American Ceramic Society, Alfred, N. Y.

In order to be considered refractory for foundry work a clay should have a softening point not lower than that of cone 26. This is rather a low temperature for refractories. A better grade refractories used for ceramic work have melting points above cone 28.

Softening Point Test with Use of Pyrometer.—The method of determining softening points of clays with the use of a pyrometer, as conducted at the bureau of standards, is as follows: The samples are worked up with water to a good working consistency and compressed into small cylinders. These are melted in a graphite-resistance vacuum furnace, the samples being protected from the reducing atmosphere. The melting point is taken as the temperature at which the samples are distinctly seen to flow. The temperatures are determined by the use of an optical pyrometer. To be classed as refractory a clay should have a softening point not lower than 1550 degrees Cent. (2820 degrees Fahr.).

Tests of Typical Clays.—In the accompanying table are given the results of tests of clays typical of the eight varieties of plastic fire clays. The method employed in making the slaking test will be described in a later section.

Table II—Results of Tests of Typical Plastic Fire Clays

Variety of plastic fire clay	Time of slaking, minutes	Vitrification temper're deg. Cent.	Softening temper're cones
Slow slaking, vitrifying, refractory	78	1125	32
Slow slaking, vitrifying, nonrefractory	97	1175	20
Slow slaking, nonvitrifying, refractory	113	1290	31
Slow slaking, nonvitrifying, nonrefractory	52	1360	24
Quick slaking, vitrifying, refractory	27	1200	32
Quick slaking, vitrifying, nonrefractory	26	1195	24
Quick slaking, nonvitrifying, refractory	6	1475	32
Quick slaking, nonvitrifying, nonrefractory	10	1290	21

Clays Suitable for Refractory Mortars.—Vitrifiable plastic fire clays with high softening points and ball clays are especially suited to be used as batter material where fire brick construction is to be exposed to cutting flames or to the action of slags.

These clays burn to dense, hard masses at comparatively low temperatures, around 1200 degrees Cent. (2200 degrees Fahr.), but do not fuse until high temperatures above 1600 degrees Cent. (2900 degrees Fahr.) are reached. They have no injurious effects on the fire clay brick with which they are in contact. For conditions in which resistance to heat is the only requirement very refractory nonvitrifiable clays are available.

High Temperature Cements.—In the past few years several firms have advocated the use of more or less fusible or vitrifiable cements as batter or mortar for furnace construction. The idea is that the partial fusion of these cements will result in the bonding together of the brick work into one solid mass. This is claimed to resist the cutting action of slags more effectively than fire-brick work constructed with the use of refractory clay as batter. It is true that a slightly vitrified mortar joint is more resistant under the conditions described than a soft, earthy joint, especially if the joint is thick. However, the use of fusible batter with fire brick must be practiced with caution. The use of a too fusible cement has resulted in some cases in the partial fusion and rapid deterioration of high grade fire bricks. No extensive piece of construction involving the use of fusible cements should be undertaken until careful experiments have shown the employment of these to be desirable. These materials should be tested while in contact with the kind of brick with which they are to be used and under conditions approximating those that will exist in the furnace that is to be built. In cases of doubt as to the best material to use for mortar joints in fire clay brick construction, the safest course is to use a properly selected clay for mortar.

Daubing Clays

Compositions Used.—Clays are used extensively in foundries in the lining of ladles and in repairing cupolas. The plastic vitrifiable type of fire clays is the kind employed for these purposes. These clays are seldom used alone but nearly always mixed with large amounts of sand. In place of sand, granulated fire brick may be employed. The object of the addition of nonplastic material is to avoid the cracking in drying and baking that

would occur with most clays if they were used alone. The tendency of these mixtures to crack may be reduced still further by the addition of about 0.5 per cent of common salt.

Tests of Raw Clay.—In order that the mixtures containing large amounts of nonplastic material may be plastic when wet and may dry to fairly coherent masses, it is necessary for the raw clay to have considerable bonding power. For these uses this requirement can usually be met by specifying that the clay shall be plastic. If more definite specifications in this respect are desired, bonding strength tests can be made as described later in this paper.

Tests of Burned Clay.—These mixtures should bake to hard masses, or partially vitrify, at comparatively low temperatures and should not soften until high temperatures are reached.

Of course empirical service tests of the adaptability of clays for these uses can be made readily in a foundry. However, this sort of test does not give data that can be used as the basis of specifications for the purchase of similar material. As a basis for the purchase of clays for these uses by specifications, vitrification and softening point determinations are desirable. Theoretically these determinations should be made on the mixtures to be used rather than on the clays alone. It might seem preferable also to make tests in contact with the slags and metals with which these mixtures will come in contact in use. Practically, however, the making of standardized tests of these kinds are accompanied by great difficulties. Moreover the effect of admixture of moderate amounts of a given nonplastic material or of contact with a given metal or slag is about the same with all clays of a certain class. Therefore it seems sufficient to make vitrification and softening point tests on the clay alone as described in the section on the use of clays for mortar.

Clays in Furnace Bottom Mixtures.—Closely allied to the use of clays for daubing mixtures is the occasional employment of clay as an ingredient of the mixture used in making and repairing the bottoms of acid open-hearth furnaces. Since these mixtures are simply shoveled into the furnace, plasticity

and bonding power in the raw state are not required of the clay. Provided it is ground sufficiently fine to form an intimate mixture with the sand, the physical properties of the raw clay are unimportant.

According to the kind of sand used and the proportions of sand and clay used in the mixture, a vitrifying or a nonvitrifying fire clay should be used. In general the softening point of the clay should be high. Vitrification and softening point determinations can be made as indicated in earlier sections of this paper.

Clays in Steel Molding-Sand Mixtures

Requisite Properties of Clays.—Plastic fire clays are used extensively in sand mixtures for molds for steel castings in both green-sand and dry-sand mold making. The function of the clay is to act as a bonding material, alone or in conjunction with other binders, such as molasses, and thus to render the mixture plastic when wet and enable it to hold its shape when partially or wholly dry. The requirements of a clay for this use are that it be readily miscible in a very intimate manner with large proportions of sand and a small amount of water, that it have considerable bonding power when wet, and that it shall not form mixtures that vitrify at the temperatures at which steel is poured. For dry-sand molding, a certain amount of bonding power in the dry state is required, but practically every clay that has sufficient bonding power when wet will be satisfactory in this regard when the molds are dry.

Slaking Test.—In order to be readily miscible with sand and water in the sand-mixing machines in use in steel foundries, a clay must either be finely ground or slake down rapidly to a fine powder when wet. A quick slaking clay does not need to be finely ground for this class of work, but a slow slaking clay must be very finely ground and thoroughly blended dry with the sand if an intimate mixture is desired in the wet composition. The slaking properties of ground clays can be determined in the following manner:

Mixtures of the clay to be tested are made with potter's flint in the proportions of 1 to 1 by weight. These are mixed with water and molded into cubes 1 inch square and dried first at atmospheric temperatures and finally at 110 degrees Cent. The cubes are then placed on a piece of ½-inch mesh wire screen and immersed in water at room temperature. The time required for the whole sample to slake and settle through the screen is taken as the time of slaking of the sample of clay. Several determinations should be made and the average taken as representative of the time of slaking of the clay.

Clays vary greatly in the readiness with which they slake in water. In the testing of 28 clays at the bureau of standards it was found that the time of slaking varied from 5½ to 128 minutes. Fat, sticky clays require much longer time for slaking than short, sandy ones. However, as stated above, the rate of slaking of fat clays can be accelerated by fine grinding.

Bonding Power Test.—The bonding power of clay in wet mixtures of clay and sand varies so greatly with the relative amounts of clay and sand, the amount of water, the size of grain of the sand or sands, and the method of making the test specimens, that it seems necessary for each foundry to make tests of this property on the particular mixture employed in that plant. The clays cannot be tested alone for the strength of some clays is increased by the addition of sand while that of others is decreased. The moduli of rupture of the dried mixtures cannot be taken as an indication of the bonding power in the wet condition of the clay. It has been found that certain kinds of clays, such as the adobe clays of the Southwest and the loess clays of the Middle West, have high moduli of rupture in the dry state but practically no bonding power in the wet condition. On the other hand most clays that have high bonding power when wet have considerable strength when used in dry sand mixtures.

The bonding power of a clay in a wet sand mixture is determined in the foundry laboratory of the bureau of standards by making a shearing strength test as follows: Bars, of the mixture to be tested, 12 inches long by 1 inch square

in cross section, are molded in a snap flask on a smooth glass plate. The sand is first gently rammed with the thumb and forefinger of each hand and then firmly rammed once with a round wooden bar from one end to the other. Then the flask is removed, the sand bar being left on the plate. The bar is then gently shoved lengthwise over the plate at about the rate of 1 foot a minute until it breaks off. The weight of the portion of the bar breaking off is the shearing strength per square inch of the mixture. Several determinations can be made on the same bar, and several bars should be tested in order to get a fair average.

In this test it will be found that fat sticky clays, especially the fine-grained ones, have greater bonding power than short, sandy ones. This agrees with the fact that it has been found practicable to use a smaller percentage of finely ground fat clays in clay-sand mixtures than of sandy clays.

Vitrification Test.—A clay-sand mixture that vitrifies or bakes to a hard mass at steel pouring temperatures is liable to give a high sand loss and castings that are hard to clean. A thick layer of caked sand will adhere to the castings. To determine the probability of this occurring with a given mixture, vitrification tests of the clay alone cannot be used. With the small amounts of clay employed in these mixtures vitrification is brought about by the actual fusion of a mixture of clay, the finest of the sand grains, and the surface layers of the coarse sand grains. The temperature at which this takes place bears no relation to the temperature at which the clay alone vitrifies. It is more nearly, but not directly, related to the softening point of the clay. It may be said that if a clay does not soften at steel melting temperatures, it will not give vitrified clay-sand mixtures. On the other hand if it does soften at or below steel melting temperatures it will or will not give vitrified clay-sand mixtures according to the kind of sand used and proportion of clay in the mixtures.

For the foregoing reasons it is desirable to test the clay-sand mixture to be used. The mixture for the vitrification test should be heated to the temperature used in pouring steel in the

foundry using the mixture. In other respects the test should be conducted as described in the section on refractory mortars.

Clays with high softening points are generally preferred for clay-sand mixtures used in making molds for steel castings. However, some clays with low melting points are used successfully. In tests conducted at the bureau on clays actually used in steel facing sand mixtures it has been found that the softening points varied from 1180 degrees Cent. (2150 degrees Fahr.) to 1600 degrees Cent (2900 degrees Fahr.). The clays with low softening points have great bonding power and are used in such small proportions in the mixtures that they do not cause vitrification.

The Place of Chemical Analyses in the Testing of Clays.— Chemical analyses have little place in the testing of clays for foundry uses. The value of clays for these uses is dependent on the physical properties of the clays, such as ease of slaking, bonding power, vitrification behavior and softening point. The relations between these properties and chemical composition are so obscure that it is impossible to estimate them in a given clay from a study of either its ultimate chemical analysis or the so-called rational analysis.

No relationships have ever been established between composition and such properties as ease of slaking and bonding power. The relationships between chemical composition and vitrification temperature and softening point are very general. It is possible to say that a clay having a composition corresponding very closely to that of pure clay substance (39.8 Al_2O_3, 46.3 SiO_2, 13.9 H_2O) will have a high melting point and that a clay whose analysis shows the presence of large amounts of fluxing oxides, such as lime, soda and potash, will have a lower softening point. It is not possible to estimate the melting point with any accuracy in either case. The vitrification and softening points of a clay depend not only on its chemical composition but also on the state of chemical combination of the various elements, that is, on the kinds of minerals present, and on the size of grain of these minerals.

Discussion—Testing Clays for Foundry Use

MR. R. F. HARRINGTON.—A number of years ago Dr. Moldenke introduced a method whereby the plasticity of clays could be tested by the use of a malachite green dye. Since then the laboratory of the Saunders & Franklin Co. at Providence has developed a method in which a crystal violet dye is used for determining the plasticity of clay. I have done quite a little work along these lines and have found the test well worth while and I would like to ask Mr. Staley if he has considered that method in his tests.

MR. H. F. STALEY.—The ceramic division of the bureau of standards experimented for several years with the use of dyes and as a result of this work decided that this test is not reliable and does not use it. The bureau found that impurities in the clay absorb the dye. It found also that if a man were attempting to select his clay by the dye test, he would not get results which he could not use in factories as well as he could by selecting clays according to his past experience in the use of those particular clays. There has never been a satisfactory method devised for determining the plasticity of clays.

DR. RICHARD MOLDENKE.—There is no doubt that the dye test is not as satisfactory as it might be. Saunders & Franklin improved my own work. We were only trying to find something that foundrymen could use. I was wondering how many foundries in the country could make use of the information just given in the paper. They have no laboratories to go into the subject so deeply. The dye test is a simple one and I have always found it to work satisfactorily enough for the purpose intended.

Instead of buying good clay, many foundrymen dig clay from their backyards, daub their cupolas and wonder why, after the seventh or eighth heat, they have to reline at the melting zone. This means money, work, lots of labor expense,

a pile of slag and many lost castings. I would like to see the bureau of standards take the clay dug in the backyard and show the foundrymen just what they are up against. If some homely examples were given they would begin to think.

Mr. Harrington.—Mr. Staley has pointed out the necessity of using a plastic clay in a facing sand where clay is used to replace a portion of the new molding sand. We want to keep the sand as open as possible, and if we are not particular in obtaining a plastic clay, we are going to close up the voids in the sand. There are plenty of clays in New Jersey that are plastic and yet entirely refractory enough for the average gray iron facing work, and this test—either malachite green or crystal violet—will give a very fair test of the clays and their value as a binder for use in facing sand. The founder gains nothing by the use of the cheaper and less plastic clays, as by so doing, because of the fact that for the same binding strength much more of the less plastic clay must be used, he closes up his facing or heats to the point where scabbed castings are inevitable.

When things were booming and there was not enough labor to do the work the night laborer who was mixing the daubing for the day used beach sand instead of fire sand by mistake. When we were using the fire sand, we frequently complained that while it was entirely refractory it did not stay on the walls as well as it should. When, by mistake the beach sand was put in, we noticed that the daubing actually vitrified on the bricks and remained there four or five times as long and gave a sufficiently refractory material so that it really was better to use the beach sand.

Mr. Staley.—In general the clays which are used by the crucible manufacturers and which were formerly imported from Germany belong in the class of plastic, vitrifiable, refractory clays; that is, they vitrify at comparatively low temperatures, do not melt until very high temperatures are reached, and are clays which have high bonding power. It has been found that there are clays in this country which can be mixed together and produce mixtures which will take the place of the German clays but we have no one clay which answers.

Refractory Cements

By W. S. Quigley, New York

The title I have chosen for this brief paper is purposel. selected to bring out a point with reference to high temperature cements on which there is some misapprehension. A refractory cement is not of itself just a refractory but bears its title from the fact that it is used as a binder for refractories. There is probably not a commodity used today by manufacturers in general that is as little understood or as much overrated as are high temperature cements.

In foundry circles there has been a great deal of educational work done during the past two or three years on the use of refractory cements, and while their successful application is well understood by many foundrymen there remains much information yet to be uncovered on the whole subject of their many and varied uses. Their use sprang up rapidly during the war owing to the necessity for using a material for bonding refractories which, by increasing the life of linings, would prevent shutdowns and by the use of which repairs to furnaces could be quickly made.

Bonding materials may be divided into four classes.

First we have fire clay, the primary function of which is to compensate for the inequalities of the bricks or shapes as a pliable refractory filler, and with which unduly thick joints generally are made. It has no binding strength of itself unless subjected to a vitrifying temperature. Furthermore, inasmuch as heat is required for vitrification in order to obtain a bond, it is obvious that only a surface bond is obtained, as the required heat for vitrification will not penetrate the entire thickness of the wall. The result obtained may be likened to a vitrified shell with a weak structural backing. Furthermore, the shrinking of the fire clay due to its own moisture and the combined water used in mixing it, causes a separation between the bricks or shapes in walls or arches which frequently results in bulging walls or collapse of the whole structure.

Secondly we have coarse grades of mixed materials or

so-called cements which also have no binding quality, depending upon heat or vitrification for a bond. Materials of this class must be made to bind or fuse at approximately the same temperature at which the furnaces are run, or no bond is effected. In other words, a cement which is good for a low temperature annealing furnace is not good for a high temperature forging furnace, or vice versa. Such mixtures are subject to the same surface bonding result as fire clay.

Thirdly, some cements in order to hold the component parts together depend upon a fibrous structure which shrinks and eventually loses its binding value as soon as subjected to any considerable degree of heat. Such cements must lose their effectiveness as the temperature increases.

Finally, to be universal in its application, a cement should air set and not depend upon heat for creating the bond in order to form a union throughout the structure. In process of manufacture it should be passed through a fine mesh sieve so as not to contain coarse particles which would tend to create voids between the brick. It should not shrink when subjected to heat. It should be a material which can be used as a binder with crushed fire brick, old crucibles, fire sand or fire clay, ganisters, and for making rammed-in linings, and doing repair work, hot or cold. And furthermore, its composition should be such that it can be used in neat form for making small hot patches and repairs.

The principal essential of a refractory cement is that it should have at various temperatures, the same co-efficient of expansion, as nearly as possible, as the materials with which it is used for bonding. Refractories themselves differ in expansion co-efficient, as in the case of fire-clay brick and silica brick, where the former has 0.075-inch and the latter 0.175-inch per foot at 2200 degrees Fahr.* Yet a cement with a co-efficient which lies between these two could be advantageously used with both refractories.

The difference in the cost between fire clay and high temperature cements must be justified by the difference in the results obtained.

*Chemical and Metallurgical Engineering, Vol. 21, No. 3, page 153.

Repairing the Broken Sternpost of the Northern Pacific

By ARTHUR F. BRAID, New York

When the 526-foot army transport NORTHERN PACIFIC ran aground in a dense fog off Fire island, Long island, N. Y., on Jan. 2, 1919, she sustained numerous injuries which required extensive repairs in the Brooklyn navy yard. The interior machinery was badly disabled, and the turbines were thrown out of alignment. A great many plates were badly battered, and had to be replaced. In addition to this, the problem arose as to what should be done with the huge cast steel sternpost, for just above the uppermost gudgeon the casting was cracked through, the cross-section of the break forming roughly a triangle, each side of which was about 2 feet in length. A view of the broken stern-post is shown in Fig. 1.

Break Was High on Casting

The high position of the sternpost break, because of the unusual circumstances which caused it, was unique in the history of stern injuries, most of which have occurred much lower down on the stern post, or on the stern shoe near its junction with the ship. The welding of this fracture also offered a special problem because the crack occurred in a hollow part of the casting, just above a solid heavy portion. The wall of the casting at the break averaged about 3 inches in thickness. The high location of the break left the huge lower portion of the casting to be supported solely by a comparatively slender horizontal stern shoe, which must have borne a terrific strain during the ship's rough treatment when she was grounded. To alleviate this strain, after arrival in dry dock, the stern shoe, which now supported most of the stern-post, was blocked up from underneath, and a wooden beam inserted in the propeller space, acting as a brace against the stern-post.

In handling this injury a mechanical repair was considered out of the question, and there remained only the alternative of making a thermit weld, or of purchasing an enormously expensive new casting and installing it at a cost probably

FIG. 1—NEAR VIEW OF STERNPOST SHOWING FRACTURE

exceeding $50,000. Although the fracture was larger than that of any marine weld ever before made, the fundamental difficulties were not greater than those of many thermit repairs of considerably larger size which are constantly being made in the steel mills. This process, therefore, was finally chosen.

To those who are unfamiliar with the process, it may be explained that thermit is a mixture of aluminum and iron oxide. This mixture is ignited by means of special ignition

powder and on reaction produces superheated liquid steel and slag (aluminum oxide), at a temperature of approximately 5000 degrees Fahr. This thermit steel is sufficiently hot to melt and dissolve any metal with which it comes in contact and amalgamates with it to form a solid homogeneous mass

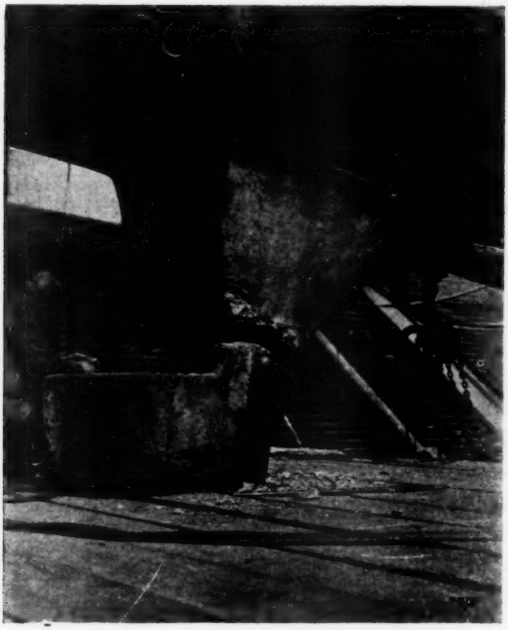

FIG. 2—FRACTURE CUT OUT LEAVING SPACE FOR THERMIT STEEL TO ENTER

when cool. In making welds by this process the parts to be united are surrounded by a mold and the sections heated red hot by means of a special preheater, after which the thermit steel is poured into the mold.

Preliminary Operations

One of the first factors in making this repair was that in overcoming the problem of inaccessibility. The sternpost

break, situated in an overhanging place about 20 feet above the floor of the drydock, necessitated the construction of a substantial scaffolding to provide a steady support for a mold box. This scaffolding consisted of a 16 x 16-foot wooden platform of 3 x 12-inch boards, erected just below the level

FIG. 3—WAX PATTERN APPLIED PREVIOUS TO BUILDING UP MOLD

of the crack. These boards rested on two horizontal 1 x 1-foot beams, which in turn were firmly supported by four vertical 1 x 1-foot beams erected on the drydock floor.

Having erected the scaffolding, the next step was to provide a space for the thermit steel to enter in bulk and form a perfect amalgamation with the broken parts. This was accomplished by cutting out a 3-inch gap at the break with an oxyacetylene torch. Careful measurements indicated that

the two parts had already separated a sufficient amount to make up for the contraction of the weld as closely as that contraction could be estimated in advance.

Applying the Wax Pattern

In order to reach the hollow interior of the casting for the purpose of supplying wax for the inside part of the wax pattern and for building up the inside of the mold, it was necessary to cut about 4 square feet of plate out of the ship's inner hull with an oxyacetylene torch. As the rudder had been unshipped from the sternpost, it now was possible to climb up from the scaffolding into a small chamber just above the hollow space of the sternpost by way of the round hole, about 2 feet diameter, of the rudder stock stuffing box. By hauling wax, tools and molding material up through this hole by means of ropes and pails, the inconvenience of having to carry this material down the series of hatchways inside the ship was avoided. A pipe connecting inside and outside workers served as a useful speaking tube when noise occurred, especially later during the preheating.

After supplying yellow wax to the hollow inside of the broken section and placing a layer of wax on the floor of the casting, molding material was deposited inside the casting and rammed up to a depth of 24 inches. Provision was made against the falling down of the molding material after the wax had burned out by inserting against the inside wall of the casting ⅝-inch iron gaggers bent inward at right angles to support the mold. A wooden cylindrical riser pattern was vertically connected with the wax on the floor of the casting. The function of a riser is to hold a supply of liquid steel which will feed into the weld during shrinkage and thus fill up any pipes that may form in the weld. It also acts as a depository, allowing any foreign material to be washed out of the weld into the riser.

The interior of the casting having been rammed up, wax was next applied to the outside of the cut out gap. A wax pattern was formed, varying from about 1½ to 2 feet in width, and

bowed upward on each side of the triangular casting at points where contact with risers was later to be made. Sixty-seven pounds of wax were required for making the wax pattern.

Constructing and Ramming Up the Mold

On completion of the wax pattern a mold box next was constructed by cutting out the desired sizes of sheet iron with an oxyacetylene flame, and bolting them into position. The finished mold box, with its base resting on the platform, had a rectangular trough-like shape, and measured 48 inches high, 51 inches on the sides parallel with the ship, 54 inches wide at the base and 10 feet wide on top.

In ramming up the mold box the total quantity of molding material used amounted to 40 barrels of backing material and six barrels of facing material.

Heating gates were provided by inserting cylindrical wooden patterns through the bottom of the box on both sides and in the rear of the weld. Pouring gate patterns were connected diagonally downward through the top of the mold with the wax pattern. For outside riser patterns a small narrow piece of a wooden plank was inserted close against each side of the triangular sternpost section and connected with the wax pattern below. These outside risers served the special purpose of supplying molten metal for the thermit collar during cooling shrinkage and thus preventing the thin casting shell at this point from sloughing away. All wooden and pipe patterns were removed before preheating.

Suspending Crucibles in Position

The suspension of the two No. 10 automatic crucibles with their extension rings over the mold box was accomplished by removing a rivet from the hull of the ship on each side, at about 10 feet above the top of the mold box, and inserting eye bolts in these holes, from which chain hoists suspended the crucibles.

The crucibles were held steadily in place by removing two additional rivets, about 2½ feet apart from each side of

the ship at the height of the crucibles and lashing the crucibles against the hull by means of steel wire cable fastened around the crucibles and run through the rivet holes into the ship, where they were tied. The base of each crucible was rested on two angle iron rails laid across the top of the mold box. Each crucible was steadied by iron pipes braced between the crucible and platform. When in place each crucible was filled with 700 pounds of thermit, making altogether 1400 pounds. Bricks were lined around the crucible extension rings.

As extra heat and fire precautions asbestos was wrapped around the chains holding the crucibles, and asbestos sheets placed between each crucible and the hull of the ship. Molding sand was scattered over the platform to prevent its catching fire.

Preheating the Mold

At 8:15 a. m. on the day of the reaction, the preheating of the mold was started. Two gasoline and compressed air preheating torches were directed through the sides of the mold box, and a third down through the riser opening in the interior of the casting. The preheating was kept up steadily for seven hours. At 3:15 p. m. the broken sections had developed a very bright heat. Pressure was then turned off and the heating gates on the sides of the mold plugged up with clay.

As the time approached for setting off the reaction, the impending "fireworks" attracted the attention of several hundred naval officers, sailors and civilian employes, and the steps at the end of the drydock served as a great amphitheater for the audience.

Both crucible reactions were set off simultaneously by men stationed on ladders near the crucibles. At 3:30 p. m., on signal, each man ignited with a red hot rod the teaspoonful of ignition powder which lay on top of the thermit. As the reaction started they jumped down and retired to a safe distance.

About 45 seconds were allowed for the liquid thermit steel to form from the reaction, after which time the two assistants tapped the crucibles by knocking up the tapping pins

with long iron rods, thus allowing the molten steel to escape into the mold. The platform had been well sprinkled with sand and there was no danger from fire. The stray pieces of aluminum oxide slag were quickly covered with sand and rendered harmless.

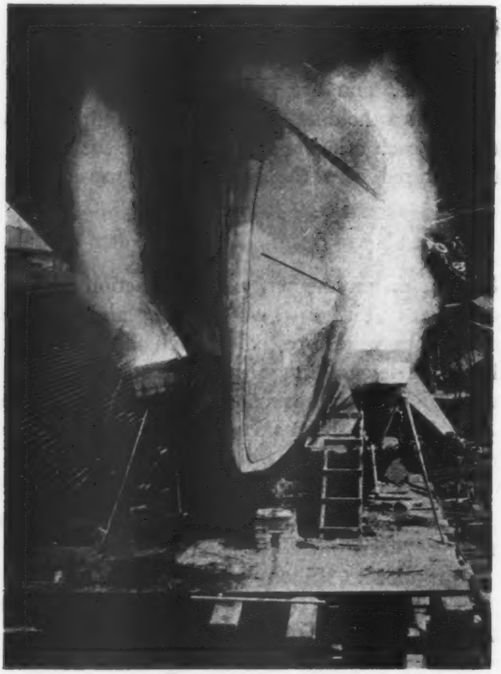

FIG. 4—VIEW OF CRUCIBLES AT TIME OF REACTION

The weld was allowed to anneal itself by cooling slowly, the mold box not being dismantled until the following day. When the molding material was finally cleared away, the risers and gates cut off with an oxyacetylene torch and the weld examined by chipping off pieces of metal, the thermit steel was

found to be of fine quality and appearance. The weld was then accepted by the navy yard representatives as being entirely satisfactory.

The total number of 14 working days taken to complete the job does not by any means represent the average time

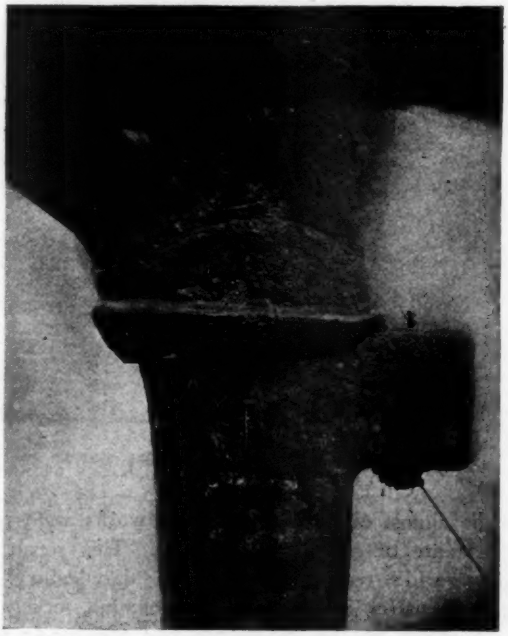

FIG. 5—CLOSE-UP VIEW OF FINISHED WELD

consumed for making sternpost welds. The other repairs on the NORTHERN PACIFIC detained her for almost four months confinement in drydock. There was, therefore, no hurry on the sternpost weld. Furthermore, this repair required extra time for erecting the high scaffolding and platform, and on account of the delay occasioned in preparing the interior of the casting. Nevertheless, had the sternpost job required more of

a rush the total time consumed on the repair could doubtless have been cut in half.

Interesting as this repair is as a record weld in the marine field, its real interest lies in the fact that as a welding operation it is of no greater magnitude than hundreds of welds which are

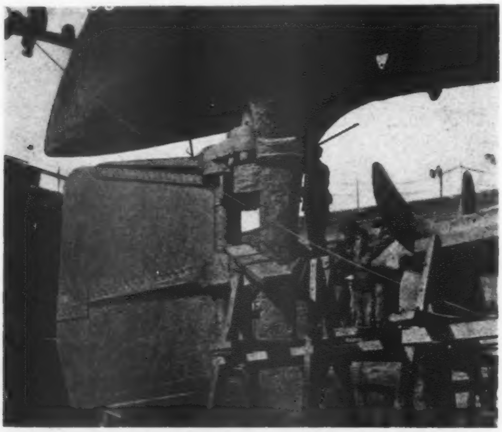

FIG. 6—WELD COMPLETED AND RUDDER SHIPPED

being made almost every day. In steel works welds of much greater size are of common occurrence. This repair did not break the world's record through any "daredeviltry" on the part of the repairer in accepting the job, but merely because no marine repair of this magnitude had previously presented itself. Much larger repairs can be completed in absolute safety whenever the opportunity occurs.

Progress in the Application of Electric Arc Welding

By Robert E. Kinkead, Cleveland

The applications of electric arc and oxy-acetylene welding have been greatly advanced as a result of the conditions brought about by the war. Conditions which produce defective castings have always existed in all foundries, but the labor situation during the period of the war brought about a state of affairs which resulted in a much larger percentage of defective castings than had ever been produced before.

The demand for skilled craftsmen in the foundry industry far exceeded the supply, and the net result was that skilled workmen were spread rather thinly through the industry. While the introduction of molding machines has to a certain extent made it possible for unskilled labor to produce a comparatively high percentage of sound castings, the application of this labor-saving device has not yet become so general, but that there are still a large number of castings which must be made in a manner which requires a high degree of craftsman's skill.

The net result of these conditions during the war was that an alarmingly large percentage of castings came from the sand that were partially or totally defective. This has led to an increased interest in and extended application of welding processes to save these castings.

In the eyes of the highly skilled craftsman, the application of welding processes to correct defects produced in the castings by poor workmanship is nothing short of sinful. However, from the point of view of the economist, welding offers a means of eliminating a large economic waste.

A casting is made to perform a certain service, and so long as it is capable of performing that service satisfactorily the methods used in its production are of secondary importance.

There is no escape from the economic pressure tending to compel the foundryman to reduce the cost of production of his castings. While there are many methods of reducing the cost of production of castings, the salvage of defectives offers some of the greatest possibilities.

In Steel Foundries

The electric arc-welding process has been used in steel foundries for about 10 years, and during that period the sentiment toward salvaging defective castings has changed in a most remarkable manner. This practice is now followed by practically every steel foundry in existence, and there is no question but that if the practice were eliminated completely today the price of steel castings would have to be substantially increased to cover the loss of labor and material resulting from rejection of defective castings. The salvaging of defective steel castings may now be said to be standard foundry practice.

The carbon electrode welding process offers one of the most important means of correcting defects in steel castings. Where this process can be used, in the opinion of the writer the work may be done cheaper and better than by any other means. However, the extensive use of the correction process has developed fields which cannot be covered by the carbon arc process. The metal electrode method of electric welding has been substituted with great success.

The field in which the metal electrode process is best applied is in dealing with small steel castings where the defect is of minor importance and in larger castings where the defect occurs in a section which is thin, and on which the heat must be extremely localized.

Good foundry practice indicates that steel castings which have been welded by the carbon electrode process should subsequently be annealed to relieve any local internal strains which may have been introduced by the application of the heat of the arc. There are occasions, however, when it is extremely inconvenient and expensive to reanneal a casting which shows a slight defect. On such occasions the application of the metal electrode process, owing to the very great localization of the

heat, will permit the correction of the defect without the necessity of reannealing. The judicious use of the metal electrode process in this direction has resulted in some attractive economies.

Until recently 5/32-inch diameter metal electrode was as large as was ordinarily used in this work. Investigations have recently shown that ¼-inch electrode, and even ⅜-inch diameter rod, may be used in the metal electrode process to good advantage on steel castings.

Welding Malleable Iron with Metal Electrode

The welding of malleable iron castings by any process is difficult. However, the metal electrode electric welding process has been used successfully and with large savings on some classes of castings.

There is no difficulty whatever in welding the outer skin of a malleable casting. The metal in the weld will be soft and the metal in the skin of the casting adjacent to the weld will also be soft, but where the soft skin of the casting is only 1/32-inch deep, difficulties may be encountered in machining the casting after it has been welded, although reannealing the casting in most cases will eliminate difficulties.

The most important application of the metal electrode welding process in malleable castings is in the plugging of sand holes in castings which are to hold oil. A large number of the castings encountered in automobile work are of this nature.

Defects in malleable castings which occur on surfaces which are not to be machined may readily be corrected by the metal electrode process, and the excess metal removed with an emery wheel. The welding on malleable iron is always done after the casting has been annealed. If the casting is to be machined at the point at which the weld is made it should be reannealed.

Progress in Welding Gray Iron

The application of the electric arc welding process to gray iron has developed with extreme rapidity within the last year. While the fundamental factors involved in the welding of cast iron have not in any way changed, there is without ques-

tion, a field of usefulness for the electric arc process which is far from developed.

Extensive and successful application of the electric welding process has been made to the repair of gray iron castings after they have left the foundry. Surprisingly successful work has been done on marine engine cylinders as well as on other large and expensive castings.

The attractive feature of this class of work is that it may be accomplished without preheating the casting. It would be far from the truth to state that any broken gray iron casting can be repaired successfully with the electric arc process, but there are many jobs which can be done and a great saving accomplished.

There are two classes of work which can be done in the gray iron foundry with the metal electrode process. In the first class are large castings which come from the sand with shrinkage cracks or low spots in parts of the casting which are not to be machined. In the case of a crack, it may be opened up with a chipping tool, and steel filled in to give a measure of strength and complete pressure tightness.

The welding can be handled with a low current, and should not be done continuously. The operator should weld for possibly 20 per cent of the time; the remainder of the time being divided up into intervals to permit the heat to be distributed throughout the locality of the weld. This practice will not harden the cast iron in the vicinity of the weld with the exception of the iron which is within 1/16-inch of the line of fusion. The steel added will not be hardened by the absorption of carbon from the cast iron for a distance greater than 1/16-inch from the line of fusion. If the welder works intermittently he will avoid having the steel shrink away from the gray iron. The difficulty in machining such a weld arises from the hard area 1/16-inch on either side of the weld.

The second class of work which can be done with the electric arc on gray iron is in the correction of small sand holes and sand spots on surfaces which are to be machined. In work of this nature the sand hole is opened up and a nickel electrode fused into the hole by the heat of the arc. The nickel is not welded to the cast iron, but at the high temperature

produced by the arc makes an intimate contact with the gray iron, which resembles an amalgamation. The nickel is then peened and the excess metal filed away. The job may be made pressure tight, and the application is entirely successful in the correction of sand spots in the bore of engine or pump cylinders. This process is not used for the repair of breaks in a casting, but is merely a method of plugging a crack or sand hole.

In the Machine Shop

Quite frequently in machining a casting defects appear which were not apparent before the casting was set up in a machine. In the case of steel castings, the metal electrode arc welding process enables the operator to correct small defects without taking the casting out of the machine, and thus permits a very great saving to be made. The application of the nickel electrode process in the correction of small flaws in gray iron castings which are discovered after the casting is in the machine tool also may result in substantial saving.

A New Cutting Gas

By ALFRED S. KINSEY, Hoboken, N. J.

Cutting steel by the principle of rapid oxidation has become so important a factor in foundries and for the repair and manufacture of metal parts that any improvement in the process is certain to be of interest. Many will recall that the first torches designed for the cutting of metals depended on the use of oxygen and hydrogen. A mixed stream of low pressure oxygen and hydrogen produced a flame which was used to heat to a bright red a small part of the surface of the metal to be cut. Then a high pressure jet of oxygen from the same torch was snapped on and allowed to project itself through the preheating flame so as to strike and cut the hot metal by instantaneous oxidation or burning.

Ignition Gas

The successful commercial manufacture of calcium carbide soon made acetylene an active competitor of hydrogen for cutting metals. This condition also brought about a careful study of the merits of an ignition gas for metal cutting. It was known that such a gas served for a moment as fuel to preheat the surface of the job, and that then comparatively a small amount of gas was required to maintain the ignition of the pure iron as the cutting progressed. It was natural therefore to suppose that for the cutting of metals, an inexpensive gas costing less per cubic foot than acetylene would readily adapt itself to the commercial demand. Hence many special cutting gases have entered the field, of which may be mentioned hydrogen, pintsch gas, blau gas, carbohydrogen, gasol, wolf-gas and natural gas.

Valuable experience has been gained from the use of these gases, and much more is now known of the qualifications of a successful cutting gas. A fallacy, probably unconsciously harbored in most instances is that the efficiency of a cutting gas depends entirely on its thermal contents in British thermal units, that is, on the total amount of heat it may be available to propagate a flame in a cutting torch. Of course this is not the case, as may be shown by a simple comparison of blau gas and acetylene. Blau gas has a heat value of 1800 British thermal units per cubic foot and acetylene 1400 British thermal units. This might indicate that blau gas would give a hotter flame than acetylene, which of course is not so, the highest temperature obtainable from blau gas being about 5000 degrees Fahr., as compared with 6300 degrees Fahr. for acetylene. The high temperature of the acetylene flame is partly due to its endothermic property but this does not entirely account for the difference in heating value of the two gases. It is not only the quantity of heat a cutting gas may contain, but of as much importance is the characteristic of the gas to release its heat units at a rate faster than the absorption by and the conduction of the heat through the metal being cut, as well as the ability of the flame to maintain its initial temperature. Carbon is the chemical element in a gas which probably will produce the most rapid rate of combustion provided it is not retarded by some other element.

Qualifications of a Satisfactory Gas

From these premises it may be seen that a successful cutting gas should be one which is unsaturated, contains a liberal amount of carbon, combined with the lowest possible proportion of a slow-burning gas, and has a high rate of combustion.

A new cutting gas, named calorene, has been developed for the purpose of meeting these conditions. It is derived from the manufacture of alcohol. It is an unsaturated gas and its analysis shows carbon 86 per cent; hydrogen, 14 per cent, and a heat value of 1580 British thermal units per

cubic foot. Some relative heat value data may be of interest:

	Carbon Per Cent	Hyd'g'n Per Cent	Ratio Carbon to Hyd.	B.T.U. per cu. ft.	Maximum Temp. Degrees Fahr.
Acetylene	92	8	11.5:1	1400	6300
*Calorene	86	14	6 :1	1580	6200
Gasol	84	16	5.3:1	2300	5000
Blau Gas	80	20	4 :1	1800	5000
Carbo-hydrogen	17	83	-5 :1	412	
Hydrogen	..	..	.....	322	4000

*The new gas.

It will be seen that acetylene has the highest ratio of carbon to hydrogen, with the new gas next in order. This largely accounts for the fine cutting qualities of these two gases, but the unsaturated nature of the gas producing a high rate of combustion also enters, and in this regard the new gas has so far been shown to be practically the equal of acetylene as a cutting gas.

Cutting Qualities of New Gas

The following brief summary data of recent tests by the author will give an idea of the cutting qualities of calorene, both on thin and thick metal:

TO CUT BY HAND TORCH 100 SQUARE INCHES OF STEEL WITH CALORENE

Material	Thick-ness Inches	Consumption Time Mins.	Consumption Oxygen Cu. ft.	Consumption Calorene Cu. ft.	Cost Labor @68c	Cost Oxygen @$1.25	Cost Calorene @$2.00	Total	Lineal feet cut per hour
Steel plate	0.41	12.04	10.66	4.73	$0.14	$0.13	$0.10	$0.37	101.5
Steel forging	2.25	6.93	22.60	2.04	.08	.28	.04	.40	32.0
Steel casting	9.00	3.5	24.55	1.66	.04	.31	.03	.38	16.0

It will be seen that while the consumption of oxygen per cubic foot increases with the thickness of the metal being cut, both the labor and consumption oi the new gas decreases. This results in maintaining a low figure for the total cost per square inch of metal cut.

A full cylinder of the new gas containing 210 cubic feet weighs 85 pounds, compared with 145 pounds for another well known cutting gas which we will call "Gas No. 3" in the following table and 250 pounds for acetylene. The following table gives this in better form, the figures showing the total weight of cylinders and gas required to be handled to cut 1,000,000 linear feet of ⅜-inch boiler plate:

Approximate Total weight of Cylinders and Gas Required to be Handled to Cut 1,000,000 Lineal Feet of ⅜-inch Boiler Plate

Kind of Gas	Cylinder			Total Weight to be handled to cut one million linear feet of ⅜-inch boiler plate, Lbs.	Relative to be weight carried
	Pressure Lbs. Sq.Inch	Capacity Cubic feet	Gross Weight Lbs.		
Calorene	1250	210	85	9000	1
Acetylene	250	250	225	29000	3.2
Gas No. 3.........	1800	200	145	69000	7.7

Kerf Surfaces

Under certain conditions some cutting gases will leave the surface on each side of the kerf, or slot, of a job covered with an oxide scale so hard that it is impossible to machine the surfaces, and even grinding is inefficient. The metal under the scale is also sometimes liable to granulation and brittlizing due to the action of the flame. The kerf scale of the new gas is about 0.008-inch thick on a 4-inch cut and always is noticeably thin and fragile, and the under surface is undisturbed in hardness as determined by the scleroscope and file. This undoubtedly is due to the rapid and efficient combustion of the gas with oxygen. In steel foundries it is often of first importance to have the surfaces of castings which have been cut left with a scale easily knocked off and with the adjoining metal soft enough to avoid dulling the edges of machine tools.

The explosibility of the new gas will be of interest to many. Its explosive range is from about 4 of calorene to 96 of air to 14 of calorene and 86 of air, as compared with a range of 3 of acetylene and 97 of air to 70 of acetylene and 30 of air. It may be compressed to 3500 pounds per square inch and stored as a free gas, no filler being required in the cylinders. This partly accounts for the lightness of a commercial cylinder of the gas. It may be brought in contact with oil and grease without danger of explosion.

It will work at low temperature, and its point of combustion is about that of illuminating gas. It has a pleasant odor, and its products of combustion are unnoticeable and harmless.

Welding Castings of Different Metals and Different Sections

By George B. Malone, Bayonne, N. J.

To be able to weld castings of different metals is one of the most important accomplishments a foundryman can possess today. A great many times it is possible to salvage an expensive casting by welding, which was unheard of a few years ago. During the war period welding came into use more than ever before, principally on account of the need for all types and classes of castings. Millions of pounds of castings were salvaged in this manner and were accepted by the government officials as being perfect in every particular. To illustrate this, in one of the large industrial plants the writer salvaged upwards of 2,000,000 pieces, the aggregate saving to the firm being $13,000 per week. A large number of foundrymen have yet to learn that castings can be salvaged by welding instead of consigning them to the scrap heap with resultant total loss.

A large pump concern with which the writer is very familiar would not accept the welding process until a few years ago. Instead when a pump cylinder was slightly porous, they would send it out and insist that it be brazed. If the brazing concern was lucky enough to save this cylinder, it would be camouflaged by painting, etc., and forwarded to the customer. While this practice is very common, the writer wishes to say that brazing should not be employed except for minor repairs on castings. In the first place, upon microscopic examination it will be noted that fine hair line cracks are easily discernible. All the time and labor that was spent in preparing the casting for brazing will be lost in a great many cases.

Weld, Don't Braze

The proper way to prepare a cylinder casting, particularly, is to preheat it and then weld, not braze. In passing, in order

to explain just what is meant by preheating intelligently, I might say that the temperature to which any piece should be preheated depends upon the metal of which it is made, its shape, size and the purpose of the preheating. To illustrate the differences in preheating temperatures, consider first a heavy piece of cast iron the shape of which should not produce any shrinkage strains when cooling, and on the other hand a light, complicated casting such as an automobile cylinder. In the first case it is very evident that the purpose of preheating is largely to save gas and labor and that the preheating can be carried to as high a temperature as a cherry red because there will be no danger from distortion or cracking. In the second case, the conditions are entirely different. The preheating must not be carried to so high a degree as to warp the cylinder and still it must be carried high enough to permit contraction without cracking when cooling. In this case, of course, the amount of gas saved by preheating is very small. In the first case, the temperature may vary from 1200 to 1500 degree Fahr., while in the second case it should never exceed 800 degrees. In other cases, where the style or type of cylinder is quite simple, a low temperature is sufficient. The writer would suggest that instruments be used to measure the heat such as thermocouples. In welding hollow castings that might have small blow holes, such as water backs, radiator castings, etc., great care must be taken. It is very important that these castings should be preheated first. There are no special instructions that can be given in these cases other than that an intelligent welder use precaution.

Welding Large Steel Castings

Large steel castings may be welded where wear is not a factor without preheating, but it is preferable in all cases particularly where iron or steel castings lie in a damp place or where they are subjected to intense cold, that they be brought to the welding temperature slowly. The reason for this is as soon as the welding torch is applied to a cold casting the chances for crystallization are good and not only will a

poor weld result but in a great many cases the casting will be rendered unfit for use.

The salvage of small castings by the welding process is something that should be considered more by the foundryman than it is at the present time. It is a well known fact that certain foundries do figure a certain percentage of loss. This loss can be reduced to a minimum by the welding process, if the writer's advice is taken into consideration, and large savings in money are assured to the foundryman who will install welding equipment. In the writer's opinion, the foundryman who has not as yet installed a welding outfit is as far behind the times as the printer who is using an old-fashioned hand press.

Welding Nonferrous Castings

In the salvaging of brass and bronze castings by welding great care must be exercised. As an illustration of the need of care in welding brass and bronze, the following incident, which took place in a plant where the writer was interested in the salvaging of castings for pistols to be used by the government in trench warfare, may be cited. All of the pistol grips were made of bronze. The need for the pistols at the time was very great. The maker was at his wit's end to know how to reclaim castings which were found to contain sand holes when received. The writer was consulted and upon a visit to the plant, he found that the tool department, which had control of the welding outfits, was using Tobin-bronze rod in trying to salvage the pistol grips. When they were polished, they showed a bright yellow or in some cases a gold streak where the grip was welded. Of course, the government inspector would not pass them and hundreds were rejected. The writer immediately straightened out this difficulty by analysis; that is, he secured from a rolling mill a welding rod with a higher copper content than that in the metal constituting the grip casting itself, and after welding 10 grips himself he had them forwarded to the polishing department and from there to the government inspector who passed them without comment. The writer wishes to impress

upon foundrymen at large that when it is necessary to weld, first consider the casting to be welded and then endeavor to secure a welding rod of an analysis similar to the casting. You will then find very little difficulty in salvaging castings and saving a great many dollars. This is particularly true in welding brass or bronze castings which may have to be polished and will show a different color at the weld.

Welding Monel Metal

A great many foundrymen have experienced difficulty in welding Monel-metal castings. Monel-metal castings are really not any harder to weld than the ordinary iron castings if the proper procedure is followed. The analysis of Monel metal shows a large nickel content and a nickel casting cannot be welded without preheating. On account of the combination of copper with the nickel in Monel metal it is easy to see that both must be brought to a rather high preheating temperature, say 1600 degrees Fahr., before the weld is attempted. After the casting is welded it should be brought again to approximately 1500 degrees and placed in hydrated lime in order to prevent any air getting access to it. Now this same principle applies to practically every type of casting.

The average foundryman will tell you that when the weld was made the casting looked first rate but 10 minutes afterward it was all cracked. The reason for this is that proper care was not taken with the casting after the weld was made. The casting should have been allowed to cool slowly and hydrated lime is the best substance that the writer is acquainted with for cooling castings slowly.

Discussion—Welding of Castings

Mr. Robert E. Kinkead.—The welding of any casting of gray iron whose failure would bring death and destruction should not be done by the electric process. In order to accomplish fusion, it is necessary to melt the cast iron. Now if there is a considerable mass of metal back of the line of fusion which is cold, it is quite evident that that small area or small volume of metal which was melted to accomplish fusion will be suddenly chilled, and that chilled iron has the characteristic of all chilled iron: it is hard and brittle. That is on the cast iron side of the line of fusion. On the steel side of the line of fusion, the steel absorbs a certain amount of free carbon in the cast iron; the result is that you have got a thin layer of high carbon steel. Such a junction (you may call one side cast iron and the other side steel) is not reliable. Any jar or dynamic stress is apt to pull the steel out of the cast iron because that chilled iron will not stand any dynamic stress. Now the way we get around that fundamental defect in the practice in repair work is through the application of steel studs along the line of the weld. Some people rely on a tensile strength of 5000 pounds per square inch of area due to that fusion between the steel and the gray iron; then, by introducing studs and welding across the studs on either side of the crack to get an additional strength due to the shearing strength of the studs and assume that they get up to 15,000 pounds per square inch tensile strength in the weld constructed in that manner. While on a great many gray iron castings, owing to the great factor of safety used in their design, such a job is entirely satisfactory.

In regard to the use of a flux, you can use any kind of a flux or welding compound or anything else, but the resultant hardening of cast iron under sudden cooling is something that cannot be affected by the introduction of any foreign substance, so far as I know, so that a flux is entirely useless.

PROFESSOR A. S. KINSEY.—In regard to the question of flux, is it not true that we use a flux in order to lower the temperature of the oxide of cast iron so that we can get it out of the way and reach the pure metal and make proper fusion? If we try to weld cast iron without attempting to remove the oxides, the fusion will not be a good one, and there will be porosity and weakness at the joints. The electric arc process uses a flux in the form of a coated metal electrode for steel welding, with that same thought in mind. I cannot quite see how a good weld can be made in an iron casting with steel as a filler rod without some attempt being made to eliminate the oxide. The fact that the arc is hot enough to melt the oxides does not necessarily mean that the weld will be a good one, because the oxides will melt in with the pure iron and leave a porous, hard weld.

In paragraph 3, page 494, the first sentence reads, "The attractive feature of this class of work is that it may be accomplished without preheating the casting" (referring to the welding of gray iron). In the fifth paragraph it is recommended that the operator should hesitate in his welding, taking only about 20 per cent of the time for each operation, in order to permit the heat to be distributed throughout the locality of the weld. I would like to ask if that would not mean preheating in order to avoid shrinkage cracks as the result of the distribution of the heat throughout the casting?

MR. KINKEAD.—The application of the metal electrode without preheating is an effort to do the work cheaper than it can be done by the oxyacetylene or with the carbon arc. If we preheat the casting, we can use either the gas process or the carbon electrode process and fill in cast iron. The job obtained following that practice will be better when it is properly done than if the job is done with the steel electrode, metal electrode process, because you are filling in the same kind of metal, probably a metal of higher grade than the metal of the original cast iron. But such a practice is quite expensive, and in pursuing this practice of using the metal electrode, we are trying to do the same job at enormously lower cost. There are some castings which have been repaired by the metal electrode process

without preheating which, had they been repaired by preheating and welding with the carbon arc or gas, would have been done at a prohibitive cost. We are dealing with an economic proposition rather than a technical one.

In regard to the use of flux, the best answer that I know of is to observe the conditions and see the character of the line of fusion obtained, using ordinary bare wire. It is not true that in the metal electrode welding we use flux. Probably not 5 per cent of the metal electrode welding now performed in the country is being done with covered electrodes. The temperature is so high that the oxide gets clear to the top in a very short length of time. We do get some oxide in the metal; we get the metal oxidized in steel welding. Under commercial conditions, even with the best covered electrodes we are able to obtain we get oxidation and we do not get an appreciable degree of ductility in the metal deposited in the weld, so that the use of flux up to the present time has not been practical. It has been an experimental proposition, and the use of flux has not justified itself on economic grounds.

MR. W. D. SPERRY.—Is it not true that cast iron must be welded quickly?

PROFESSOR KINSEY.—I believe that it is not true that any metal should be welded in the quickest possible time. From a metallurgical standpoint that is not the correct way to weld. This applies to cast iron and to steel, which it is sometimes claimed should be welded as quickly as possible to avoid expansion. We know that the result of welding under conditions where the speed is too fast is a crystalized brittle joint. We also know that where it is absolutely necessary to prevent expansion and the resultant shrinkage of a piece of steel, the arc weld will heat up the metal fast enough to accomplish a fusion of the joints without such expansion.

THE CHAIRMAN, MR. W. R. BEAN.—For the past year and a half we have been conducting experiments in the welding of standard test bars as produced in malleable iron. We have succeeded in getting within 10 per cent of the original tensile strength of the metal in a ⅝-inch diameter bar, welded in malleable iron. Tests have shown just under 45 pounds on a

companion bar showing about 40,000 or 50,000 pounds as produced. We have carried on the process under both the electric and the oxyacetylene method. We do not use, in the bars which have given us the best results, the steel rod, but use a rod of our own make which is essentially the composition of the original material, allowing something for oxidation. We weld in the hard iron state and in the annealed state, and in malleable, putting the castings through the regular process. The reason a weld cannot be produced in malleable that is machinable except in the very outer surface, is this: The extreme outer surface of the malleable castings is essentially that of a low carbon steel, as far as carbon content is concerned, and that is the controlling factor. If your sections were uniform throughout, you could weld without difficulty. The center is a high carbon content producing the carbon content of gray cast iron. When you heat that by any welding process, to the fusion temperature, the carbon which is in the graphitic or tempered form, goes back into the solution with the iron and you get, for an area surrounding the point of weld, a composition essentially that of the original white iron casting. Therefore, if an annealed casting is welded where strength is of any importance or where machining qualities are involved, it must at the same time be reannealed, else you have not a safe proposition. The danger is still there, in this, that unless extreme care is used, you get an oxidation which may, even though you have had the proper welding material, give you a weld that is not machinable and that is hard and brittle. A break cannot be welded unless it is burned down or V'd so that you can fill up to the original surface. If that is done, you can weld, but I am not willing to suggest to any one in the malleable iron industry that they weld castings and send them to their customers, except that the welding be done in parts where no particular strain comes in service. It is practical to do it and it is being done by a very considerable number of malleable foundries. There are two fields for welding, in my judgment; one in castings which are commercially produced, and the other in the repair of parts broken by accident or otherwise.

Mr. Ballard.—I would like to ask if any cutting tests have been conducted beyond 9 inches in thickness with calorene?

Professor Kinsey.—Not in these particular tests, but I call to mind castings of 11-inch steel which showed cutting results equivalent to these. We have no hesitancy about running into the thicker metals, but the feeling was that what could be done with 9-inch would supply sufficient data for any foundry or shipyard. It is well known that acetylene does begin to drop in efficiency as a cutting gas at 8 or 10 inches of thickness of metal, and that metals have been cut up to about 30 inches of thickness is true.

The principle of cutting with the oxyacetylene torch is that of burning or chemical oxidation. The pure iron in the wrought iron or steel is ignited and then it burns fast enough to send its heat on ahead, burning on through as coal would burn in a fire. Once started the cutting may be continued with only the oxygen and without the ignition gas. But this requires that the operator shall hold his hand perfectly steady as it moves along and the path of his torch must not be diverted or the fire will go out. This is a striking illustration of oxidation of metal and it is used by engineering schools like Stevens Institute of Technology, where all the students are given a course in oxyacetylene welding of metals. Of course the trouble is that the workman cannot hold his hand steady enough to keep the torch in line, and the moment he wavers he has to relight the fire. To avoid that he keeps a little flame going with the gas; that is why we need acetylene or some other ignition gas. The reason why we can cut low carbon steel is that the melting temperature of the oxide in the steel is so low that it melts first, then drops out of the way and leaves the pure iron to burn as fuel. The reason why it is easy to get the oxide out of the way is because the percentage of carbon is low in low carbon steel, running about 0.15 or 0.20 per cent. Now, if we go to a steel which is called "high carbon," that is, tool steel of anywhere from 0.80 to 1.10 per cent carbon, it contains so much carbon that it retards the melting of the oxide, and we cannot get it out of the way.

Report of Committee on Promotion and Membership

This committee was appointed by A. O. Backert, president, subsequent to the last meeting of the board of directors.

The committee met in Cleveland, May 13, at the time of a meeting of the exhibit committee. All the possible ways of reaching those foundrymen not members of this association were thoroughly discussed. While each member was left free to use that method by which he could reach those in his territory, or with whom he came in contact in person, or by a representative, it was thought best to concentrate the clerical and office work, as well as expense, in our headquarters office in Chicago. From there it was decided to send out a series of letters, to be signed by all members of the committee, setting forth as briefly and as convincingly as possible, the various activities of the association, and the very numerous advantages to be derived by members who will avail themselves of their privileges.

The association's aims are altruistic, and the impression of "selling," or "self-seeking," on our part, was to be distinctly dispelled and avoided. The committee prepared three letters, sent out about July 21, August 10 and Sept. 15, respectively. Copies of these letters are attached to this report. The applications received and approved by the board of directors for July were 35 and for August 39, total to Sept. 1, 74.

The committee plans an active personal campaign during convention week. There will be a booth at the registration desk from which membership activities will be conducted and applications received.

Each nonmember who registers will receive a neat card or folder, explaining our purposes and conveying an invitation to join. To be an active member in a real sense, is to live

more abundantly and extend the knowledge and usefulness of the individual and the institution that he serves.

To this end we dedicate ourselves that American foundrymen shall not have failed to receive knowledge of our activities and assurances of cordial welcome, should they choose our association.

Respectfully submitted,
V. E. Minich,
H. R. Atwater,
W. A. Janssen,
B. D. Fuller,
S. T. Johnston,
Alfred E. Howell, *Chairman*.

FIRST LETTER JULY 21, 1919

We who write you this letter were appointed a committee by President A. O. Backert of the American Foundrymen's Association, to invite you into our counsels.

In these days it happens that already some of us belong to too many organizations, and we are trying to reduce such activities rather than to increase them.

If you feel that way you are not different from ourselves, but we also ascribe to you the same discriminating wisdom which we profess in choosing what it is most important that we should have. Being in the foundry business there are some things about which you know there is no choice.

The technical side of your business *must be* held abreast of the *best modern practice*. Social questions, labor questions, matters of general economic, financial, or political import, questions involving differences of opinion or policies that have to do with the personal equation, all of these you may side-step; leave to the general good sense of society, or get into the thick of, just as you elect, on these we make no comment. But the *technical* side of your business? Ah! that is different! There is never a quarrel about a matter definitely, scientifically ascertainable, i. e., there has not been since the Middle Ages.

Being certain that you are decidedly interested in the technical end of your business, we say that the American Foundrymen's Association is most wonderfully planned to give to each of its members just that! The *results* of technical research by those most successful in the industry are made concrete and definite in the exhibits, are permanently available in the bound volumes of Proceedings.

The activities of the Association are briefly:

THE CONVENTION	1.	Technical Research. Presentation of Papers and Discussions. Activities of Committees.
held around October first	2.	Personal acquaintance and conversasations with men who know and do. Many valuable ideas are conveyed in hours of affable and easy interchange of experiences.
in one of the large cities between	3.	Plant Visitation.—The annual meetings are held in large industrial centers. This is made the more necessary as only exceptional cities have adequate hotel facilities and suitable buildings to house the magnificent Exhibit.
Boston and Minneapolis	4.	The Exhibit.—This comprises every tool, machine, appliance, supply or accessory useful to the foundryman. It is a living, moving gathering of the real things having to do with your business, and a man right there to explain each.
	5.	The Bound Volumes of the Proceedings, thus making a great fund of information quickly and permanently available.

We have made up a list of a limited number of foundrymen to whom we are sending this invitation. We feel that you particularly will appreciate the American Foundrymen's Association.

We enclose for your convenience, application blank which you may sign and forward to Secretary Hoyt.

We will greatly appreciate your favorable response.

Yours very sincerely,

BENJ. D. FULLER,
V. E. MINICH,
S. T. JOHNSTON,
H. R. ATWATER,
W. A. JANSSEN,
ALFRED E. HOWELL, *Chairman.*

(Please file this letter in a special file marked, "American Foundrymen's Association, 1919")

SECOND LETTER, AUGUST 10, 1919

Dear Sir:

The responses to our letter of July 21, to which we ask you to please refer, have been numerous and generous. When we say generous, we mean in their own interest. In but few

cases was our invitation to join the American Foundrymen's Association mistaken to be self-seeking on our part.

In renewing this invitation we remind you that we realize how easily new ideas are swept aside, or are left in the eddy of the busy current of daily affairs.

Secretary Hoyt informs us that the very large space at the coming Philadelphia Convention and Exhibit is oversubscribed, and efforts are being made to induce large space holders to economize, that others may be allowed a share.

We wish now to particularly emphasize the first group of activities of the Association, given in our letter of July 21, viz., "Technical Research", "Papers and Discussions." Please keep in mind that the technical questions discussed are such as are raised by the membership. As a member, you not only have the right, but you are requested to bring forward problems that interest you or have worried you, and you may have them thrashed out in the open, by the brightest minds in the practical end of the business.

The Papers Committee are now far advanced in their work for this year. Formal preparation for some specific subject suggested by you it may be rather late to expect. But the *men* will be there, who have experienced and weathered and mastered the very points that may now vex you. You can, you should, meet and know them.

Man is a gregarious animal, and being such he can only be happy and grow in the company of his fellows with kindred interests. Will you not sign and mail the enclosed application to Secretary Hoyt?

With best wishes, we are

Very sincerely yours,

H. R. Atwater,
W. A. Janssen,
V. E. Minich,
Benj. D. Fuller,
S. T. Johnston,
Alfred E. Howell, *Chairman*.

(Note: Please file in a special file marked "American Foundrymen's Association.")

THIRD LETTER SEPTEMBER 15, 1919

Dear Sir:

The meeting time of the American Foundrymen's Association in Philadelphia, is rapidly approaching. Why not be with us this year and profit by full fellowship *now?* There is much in store—

many English, French, Belgian, Scotch, Welsh, Irish, and other foreign foundrymen will be there. If they come so far, surely we Americans should appreciate *our own*. Can it indeed be true that "a prophet is not without honor save in his own country"?

Please refer to our letter and invitation of July 21, items three, four and five, which we now wish to emphasize.

"Plant Visitation"—What greater privilege? The Philadelphia Committee have made special plans for our members.

"The Exhibit"—The greatest gathering together of all the materials and appliances used, that has ever been attempted anywhere for Foundrymen. If you are "progressive," it will save you many thousands of miles of travel to see here the total of foundry equipment, under one roof, and the varieties subject to quick comparison.

Remember, please, that if you are too busy seeing and meeting and hearing, to read, that the reading is reserved for members in Bound Volumes, to digest at your leisure.

We cannot say all, without the risk that you will not read: "A word fitly spoken, is like apples of gold in pictures of silver." (Proverbs XXV-11.) We hope this conveys a nugget to you.

Will you not send your application to Secretary Hoyt? History is being made rapidly now. Save a year! We renew our invitation, and will greatly appreciate your favorable response.

Yours very sincerely,

H. R. Atwater,
W. A. Janssen,
V. E. Minich,
Benj. D. Fuller,
S. T. Johnston,
Alfred E. Howell, *Chairman.*

(Note: Please file in a special file marked "American Foundrymen's Association.")

Publicity Work of Foundry Equipment Manufacturers' Association

By FRANKLIN G. SMITH, Cleveland

One of the good things that came out of the war was the closer bond which is bringing the different peoples of the earth nearer together. Fortunately the result of the war in this respect was not confined to bringing nations nearer together, but it also affected some of us who are a little more closely connected in the common things of life here at home. The first time that the foundry equipment manufacturers as a whole had an opportunity to get together and discuss their own matters was at the solicitation of the chamber of commerce of the United States when that body was attempting to organize the war service committee. That was just a year ago, and our first get-together was at Milwaukee. We did not accomplish much before the armistice was signed, but when, at a wonderful meeting at Atlantic City, it was suggested that the committees and the associations which had been formed should be continued, we said "All right, let's be patriotic in this too." Therefore the equipment manufacturers, or rather the war service committee of the equipment manufacturers held a general meeting in February, which resulted in organizing the Equipment Manufacturers' association.

We believe that that which hurts any one manufacturer in the industry hurts us all, and that which helps one ultimately helps us all. We further believe that anything and everything which helps our customers, the foundrymen who buy foundry equipment, to get better results and to make more money from the operation of equipment bought from any of our members, will ultimately help each one of us as individual manufacturers, and we are proceeding on that basis.

We aim to get such co-operation from all of our representatives that, whenever any one of them discovers a piece

of idle equipment or equipment which is not giving proper service, he will, even though it be the product of his most aggressive competitor, render any service which he can to overcome the difficulty. If a mere suggestion is all that is necessary, it should be forthcoming. If the case requires personal attention on the part of the maker, the representative will communicate with his own house, suggesting that the house in turn take up the matter with the manufacturer of the equipment suggesting that personal attention would be to his advantage, and incidentally to the advantage of the foundry equipment industry. Every piece of idle foundry equipment around a plant hurts the equipment industry, and because it hurts the industry we are going to try to help foundrymen to get the maximum production and the greatest measure of satisfaction from it. As Mr. Minich said last night, if any of us have anything we cannot go out and root for with enthusiasm and confidence, we owe it to ourselves, to the industry and to the foundrymen, to mark it off the list and only sell that which will stand up.

We are definitely planning to reach the men inside the plant with bulletins containing real helpful information on the care and operation of foundry equipment. There will be no advertising and no propaganda connected with this service.

To Advise on Care of Equipment

Roger Babson has given us what really is the ideal of our association. He says, in speaking of general groups of manufacturers, that those made up of members who have the right spirit, who really believe that confidence reacts as confidence and that distrust reacts as distrust, that what we do to help others helps ourselves and what we do to harm others harms ourselves; "such associations are very successful, otherwise they do not work. If an association among competitors is to do any real good, there must be something in it besides an organization, a secretary and a full treasury; there must be a real interchange in the hearts of the members."

I think some real progress is being made in that direction by the Foundry Equipment Manufacturers' association.

The Registered Attendance

The following members registered their attendance at the annual meeting of the American Foundrymen's Association, Inc., held at Philadelphia, Pa., September 29 to October 3, 1919:

ABBOTT, G. W., superintendent, pipe shop, Glamorgan Pipe & Foundry Co., Lynchburg, Va.
ABBOTT, J. M., sales department, Pangborn Corp., Hagerstown, Md.
ABBOTT, M. T., vice president, Stevenson Co., Wellsville, O.
ABELL, FRED A., superintendent, Aluminum Castings Co., Cleveland.
ABORN, GEORGE P., manager, Blake & Knowles Works, E. Cambridge, Mass.
ACHODE, N. C., vice president, Phoenix Iron Works Co., Meadville, Pa.
ACKERMAN, A. H., eastern sales representative, Young Bros., Detroit, Mich.
ACKWROYD, J. W., foreman, T. H. Symington Co., Rochester, N. Y.
ADAMS, L. D., salesman, S. Obermayer Co., Chicago.
ADAMS, R. C., manager, Aluminum Castings Co., Cleveland.
ADAMS, W. J., salesman, S. Obermayer Co., Chicago.
ADAMSON, ROBERT, superintendent, Farrel Foundry & Machine Co., Ansonia, Conn.
ADDIE, T. A., vice president, American Manganese Bronze Co., Philadelphia.
AHARA, E. H., manager of manufacturing, Dodge Mfg. Co., Mishawaka, Ind.
AHRENS, J. F., eastern representative, *The Foundry*, Cleveland.
AIGELTINGER, L. W., manager, Wrightsville Hardware Co., Wrightsville, Pa.
AIKEN, H. L., manager, Crucible Steel Casting Co., Cleveland.
AITKEN, JAMES, Manufacturers Foundry Co., Waterbury, Conn.
ALBERTS, J. C., sales engineer, Cleveland Osborn Mfg. Co., Cleveland.
ALDRICH, WM., salesman, Metal & Thermit Corp., New York.
ALEXANDER, JOHN, superintendent, Harrison Safety Boiler Works, Philadelphia.
ALLAN, G. W., president, Allan & McKelvie Engineering Co., Vancouver, B. C.
ALLBRIGHT, W. A., district sales engineer, Pangborn Corp., Hagerstown, Md.
ALLISON, ANDREWS, general foreman, National Malleable Castings Co.,
ALLO, G. FRED, foreman, Canadian Pacific Railway Co., Montreal, Canada.
ALMUD, F. B., manager, Springfield Facing Co., Springfield, Mass.
ALPIN, EDWARD, manager service section, Chicago Pneumatic Tool Co., Chicago.
ALSON, G., foreman, Illinois Malleable Iron Co., Chicago.
ALTEN, GEO. H., manager, Altens Foundry & Machine Co., Lancaster, O.
AMON, J. H., president, Monarch Foundry Co., Detroit.
ANDERSON, E. F., salesman, Norton Co., Worcester, Mass.
ANDERSON, JAMES, superintendent Bethlehem Ship Building Corp., Elizabeth, N. J.
ANDERSON, JOHN T., superintendent, Davenport Machine & Foundry Co., Davenport, Iowa.
ANDERSON, NILES, president, Debevoise-Anderson Co., New York.

ANDRESEN, A. C., manager, service department, Chicago Pneumatic Tool Co., Chicago.
ANDREW, S. A., general manager, Fisher & Norris, Trenton, N. J.
ANDREWS, C. E., manager, Whitehead Bros. Co., Providence, R. I.
ARMOUR, JAS. J., foundry superintendent, Studebaker Corp. of America, South Bend, Ind.
ARMOUR, J. S., general manager, The Hausfeld Co., Harrison, O.
ARMSTRONG, C. P., publicity agent, Link Belt Co., Philadelphia.
ARNOLD, H. L., secretary and treasurer, Terre Haute Malleable & Mfg. Co., Terre Haute, Ind.
ARNOT, H. V., superintendent Strong Steel Foundry Co., Buffalo.
ASPERRY, J., secretary, Munnsville Plow Co., Munnsville, N. Y.
ATWATER, H. R., vice president, Cleveland-Osborn Mfg. Co., Cleveland.
AUBREY, T. J., purchasing agent, Manufacturers Foundry Co., Waterbury, Conn.
AVEY, D. M., associate editor, *The Foundry*, Cleveland.
AYERS, E. M., general manager, Interstate Sand Co., Zanesville, O.

BACKERT, A. O., vice president and general manager, Penton Publishing Co., Cleveland.
BACON, CHAS. C., secretary, Ross Tacony Crucible Co., Philadelphia.
BADEN, LOUIS, superintendent Niles Tool Works, Hamilton, O.
BAER, CHAS. F., Pilling & Crane, Philadelphia.
BAILLOT, ALPHONSE, superintendent, Hull Iron & Steel Foundries, Ltd., Hull, Que., Canada.
BAIRD, W. ED., manager foundry department, American Gum Products Co., New York.
BAKER, D. G., consulting engineer, Abendroth Bros., Port Chester, N. Y.
BAKER, J. E., engineer, Westinghouse, Church, Kerr Co., New York.
BALDWIN, R. L., United States Steel Corp., New York.
BALL, W. H., JR., superintendent, Morgan Engineering Co., Alliance, O.
BALLARD, EGBERT H., superintendent steel foundries, General Electric Co., Lynn, Mass.
BANNISTER, HORACE, Geo. Oldham Son & Co., Philadelphia.
BARBER, WM. H., chief patternmaker, Brown & Sharpe Mfg. Co., Providence, R. I.
BARENDT, FRED A., general foreman, Hooven, Owens, Rentschler Co., Hamilton, O.
BARKER, CHAS. M., district manager, The S. Obermayer Co., St. Louis.
BARKER, JOHN A., The S. Obermayer Co., Pittsburgh.
BARLOW, ARTHUR E., secretary and treasurer, Barlow Foundry, Inc., Newark, N. J.
BARNES, A. J., director of publicity, Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.
BARNES, ROBERT J., salesman, Whiting Foundry Equipment Co., Harvey, Ill.
BARR, H. E., manager sales, promotion department, *The Iron Age*, New York.
BARROWS, W. A., JR., president, Thomas Iron Co., Hokendauqua, Pa.
BARTELS, W. A., mechanical engineer, General Electric Co., Erie, Pa.
BARTLETT, E. R., foreman, Oil Well Supply Co., Oil City, Pa.
BASCH, D., research engineer, General Electric Co., Schenectady, N. Y.
BASHLINE, J. M., secretary, Star Drilling Machine Co., Akron, O.
BASSETT, W. H., superintendent American Brass Co., Waterbury, Conn.
BASSINI, L. M., superintendent, Burnside Steel Co., Chicago.

Bastedo, A. E., manager boiler department, Lord & Burnham Co., Irvington, N. Y.
Batten, G. C., foundry superintendent, Lunkenheimer Co., Cincinnati.
Battenfeld, C. F., Michigan manager, The United States Molding Machine Co., Cleveland.
Battenfeld, J. L., sales manager, The United States Molding Machine Co., Cleveland.
Battenfeld, J. N., president, The United States Molding Machine Co., Cleveland.
Bauer, Fred W., salesman, Rogers Brown & Co., Cincinnati.
Baur, C. S., advertising manager, *The Iron Age*, New York.
Baxter, D. D., salesman, E. J. Woodison Co., Rochester, N. Y.
Bayer, John, salesman, Federal Foundry Supply Co., Cleveland.
Bean, W. R., research department, Eastern Malleable Iron Co., Naugatuck, Conn.
Beatty, William G., production manager, Beatty Bros., Ltd., Fergus, Ont., Canada.
Beck, S. J., superintendent foundry, Pusey & Jones, Wilmington, Del.
Bedworth, Robert E., metallurgist, Westinghouse Electric & Mfg. Co., Pittsburgh.
Beebe, E. P., treasurer, *The Iron Age*, New York.
Beesting, N. J., demonstrator, Norton Co., Worcester, Mass.
Beherns, H. R., foreman, Henry E. Pridmore, Chicago.
Beherns, Paul, foreman, Utica Heater Co., Utica, N. Y.
Beihl, C. W., superintendent Center Foundry & Machinery Co., Wheeling, W. Va.
Beirne, John, manager business promotion and advertising, Bullard Machine Works, Bridgeport, Conn.
Beles, Joseph O. T., Geo. Oldham Son & Co., Philadelphia.
Bell, Daniel, foreman foundry, Dominion Coal Co., Ltd., Glace Bay, N. S.
Bell, F. H., editor, MacLean Publishing Co., Toronto, Can.
Bell, M. A., St. Louis manager, E. J. Woodison Co., St. Louis.
Bell, Richard S., foreman, New Jersey Zinc Co. of Pennsylvania, Palmerton, Pa.
Bement, R. E., engineer, Novo Engine Co., Lansing, Mich.
Bendixen, P., general superintendent, Bettendorf Co., Bettendorf, Iowa.
Benham, W. D., salesman, Rogers, Brown & Co., Philadelphia.
Bennett, T. Ben, foundry superintendent, Maxwells, Ltd., St. Marys, Ont., Canada.
Bennett, William B., production engineer, Union Steel Casting Co., Pittsburgh.
Bentley, W. D., general superintendent, Kinite Co., Milwaukee.
Berg, C. A. F., branch manager, T. P. Kelly & Co., Inc., Worcester, Mass.
Bergersen, Ole B., assistant advertising manager, *The Iron Age*, New York.
Bergman, R., planer, Bethlehem Shipbuilding Corp., Elizabeth, N. J.
Bettendorf, E. J., secretary, Bettendorf Co., Bettendorf, Iowa.
Bickey, Emmett H., property manager, Abram Cox Stove Co., Philadelphia.
Biggerstaff, James W., superintendent of foundry, American Locomotive Co., Schenectady, N. Y.
Bilton, C. E., president, Bilton Machine Tool Co., Bridgeport, Conn.
Bjorkstedt, William, chemist, Bayonne Steel Casting Co., Bayonne, N. J.

BLACK, DAVID, superintendent, Estate Stove Co., Hamilton, O.
BLACKMORE, WILLIAM, assistant superintendent, National Malleable Castings Co., Sharon, Pa.
BLACKWELL, H. E., district sales manager, Pickands, Mather & Co., Cleveland.
BLACKWORD, U. F., vice president, Union Steel Casting Co., Boston.
BLAIR, J. S., vice president and treasurer, Pattin Bros. Co., Marietta, O.
BLAKE, E. E., agent, Saco Lowell Shop, Biddeford, Md.
BLANERY, FRED J., melter, Driver-Harris Co., Newark, N. J.
BLOOM, EDW. B., Metal & Thermit Corp., Pittsburgh.
BLUNDELL, FRED, secretary, Taylor & Boggis Foundry Co., Cleveland.
BOCKENKAMP, CHARLES, De Kalb, Ill.
BOLDERMANS, DANIEL, sales engineer, Whiting Foundry Equipment Co., Harvey, Ill.
BONNER, ARTHUR, treasurer, Kutztown Foundry & Machine Co., Kutztown, Pa.
BOONE, C. L., Consolidated Press Co., Hastings, Mich.
BOOTH, CARL H., vice president, Booth Hall Co., Chicago.
BORGHARDT, J. H., Dayton Steel Foundry Co., Dayton, O.
BORGNIS, E. C., International Molding Machine Co., Chicago.
BORTZ, FRANK, foreman, Malleable Iron Fittings Co., Branford, Conn.
BOSCHERT, R. E., treasurer, Dunning & Boschert Press Co., Syracuse, N. Y.
BOUGHER, H. M., treasurer, J. W. Paxson Co., Philadelphia.
BOURNE, R. H., vice president, Whiting Foundry Equipment Co., Harvey, Ill.
BOUTON, W. S., purchasing agent, Clearfield Machine Shops, Clearfield, Pa.
BOWEN, JESSE J., sales engineer, Pangborn Corp., Hagerstown, Md.
BOWER, C. J., salesman, American Manganese Bronze Co., Philadelphia.
BOWERS, WILLIAM, foreman, American Aluminum Metal Co., Irvington, N. J.
BOYD, JAMES, foreman, Moore Bros. Co., Elizabeth, N. J.
BRACK, EDMUND D., department superintendent, Ajax Metal Co., Philadelphia.
BRADBURN, C. A., service man, Oxweld Acetylene Co., Newark, N. J.
BRADLEY, W. P., superintendent, American Bridge Co., Ambridge, Pa.
BRAID, ARTHUR F., sales manager, Metal & Thermit Corp., New York.
BRANDON, M. F., superintendent, Graceton Coke Co., Graceton, Pa.
BRANT, WILLIAM J., Pittsburgh.
BRAUCHER, P. S., foundry manager, Philadelphia & Reading Railway Co., Reading, Pa.
BRAY, JOHN W., sales manager, Bullard Machine Tool Co., Bridgeport, Conn.
BRAYER, FRANK N., president, Co-operative Foundry Co., Rochester, N. Y.
BRAYER, WALTER G., Co-operative Foundry Co., Rochester, N. Y.
BREGOWSKY, IVAN M., consulting engineer, Chicago.
BRIGGS, W. C., district manager, Shepard Electric Co., New York.
BRIGHTNELL, J. C., salesman, The Ajax Metal Co., Philadelphia.
BRITON, J. J., service man, Oxweld Acetylene Co., Newark, N. J.
BRITTEN, A. J., foreman, Capitol Foundry, Hartford, Conn.
BROCKMAN, PERCY A., superintendent American Car & Foundry Co., Huntington, W. Va.
BROOKS, PAUL, Philadelphia manager, Debevoise-Anderson Co., New York.

BROUCH, EDWARD N., superintendent, Kennedy Foundry Co., Baltimore.
BROWN, A. L., superintendent, Star Drilling Machine Co., Akron, O.
BROWN, ALBERT M., Philadelphia sales manager, Chicago Pneumatic Tool Co., Philadelphia.
BROWN, DAN, superintendent, C. R. Bohn Foundry Co., Detroit.
BROWN, H. W., secretary, Tabor Mfg. Co., Philadelphia.
BROWN, JAMES A., superintendent, Foster & Merriam, Meriden, Conn.
BROWN, L. K., secretary, Interstate Sand Co., Zanesville, O.
BROWN, L. OWEN, engineer, Westinghouse, Church, Kerr Co., New York.
BROWN, WILLIAM, foreman, Cleveland Co-operative Stove Co., Cleveland.
BROWNE, D., Stanley G. Flagg Co., Philadelphia.
BRUNGER, H. L., works manager, Aultman-Taylor Machine Co., Mansfield, O.
BRUNNER, FRED J., secretary, Hill Brunner Foundry Supply Co., Cincinnati.
BRYAN, R. J., mechanical engineer, American Steel Foundries, Pittsburgh.
BRYANT, R. E., vice president, Jefferson Union Co., Lexington, Mass.
BUCH, J. EARL, sales engineer, Buch Foundry Equipment Co., York, Pa.
BUCH, R. S., president, Buch Foundry Equipment Co., York, Pa.
BUCHANAN, J. SCOTT, Allegheny Foundry Co., Pittsburgh.
BUCKWALTER, CHAS. F. P. assistant sales manager, David Lampson's Son Co., Philadelphia.
BUDLONG, I. J., sales manager, American Wood Working Machine Co., Rochester, N. Y.
BUEATING, O. W., Union Switch & Signal Co., Swissvale, Pa.
BUFANA, FRANK, chief electrician, T. H. Symington Co., Rochester, N. Y.
BULL, R. A., vice president, Duquesne Steel Foundry Co., Coraopolis, Pa.
BULLARD, S. H., vice president, Bullard Machine Tool Co., Bridgeport, Conn.
BUNTE, NEAL, superintendent, General Chemical Co., Pulaski, Va.
BURCHARD, M. H., industrial representative, Westinghouse Air Brake Co., Chicago.
BURGEN, P. H., foundry superintendent, Lane Mfg. Co., Montpelier, Vt.
BURGER, J. A., machine foreman, American Abrasive Metals Co., Irvington, N. J.
BURKE, PATRICK, foreman, A. P. Smith Co., East Orange, N. J.
BURNER, CHAS. E., manager boiler department, Abram Cox Stove Co., Philadelphia.
BURR, FRANK H., director, foreign department, Cleveland Pneumatic Tool Works, Cleveland.
BURR, JOHN W., president, Burr & Houston Co., Brooklyn, N. Y.
BURRILL, WALTER M., foreman coreroom, Manufacturers Foundry Co., Waterbury, Conn.
BUSCH, J. W., foundry superintendent, Chapman Valve Co., Springfield, Mass.
BUSS, JACOB, foreman, Albany Foundry Co., Albany, N. Y.
BYERLIN, E. J., sales engineer, Cleveland-Osborn Mfg. Co., Cleveland.

Cairn, Andrew, superintendent, pattern department, General Electric Co., Pittsfield, Mass.
Caldwell, J. C., chemical engineer, Ludlow Valve Mfg. Co., Troy, N. Y.
Callender, A. R., manager Badger Foundry Co., Racine, Wis.
Callomon, C. B., foundry superintendent, Driver-Harris Co., Harrison, N. J.
Callow, W. K., sales manager, Debevoise-Anderson Co., New York.
Cambridge, A. E., salesman, Sterling Wheelbarrow Co., Milwaukee.
Camp, Geo. F., manager, Waterbury Casting Co., Waterbury, Conn.
Campbell, C. M., West Steel Casting Co., Cleveland.
Campbell, H. L., metallurgist, Industrial Works, Bay City, Mich.
Campbell, Johnston, superintendent Lehigh Valley Coal Co., Drifton, Pa.
Campion, E. I., superintendent, Canadian Steel Foundries, Montreal, Que.
Cannon, G. L., representative, Berkshire Mfg. Co., Cleveland.
Cannon, G. W., vice president, Campbell, Wyant & Cannon Foundry, Muskegon, Mich.
Carey, James A., resident manager, Hill & Griffith Co., Pittsburgh.
Carliss, Oswald, salesman, Grimes Molding Machine Co., Detroit.
Carman, E. S., secretary, Cleveland-Osborn Mfg. Co., Cleveland.
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Carpenter, H. A., manager, General Fire Extinguisher Co., Providence, R. I.
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Carroll, J. J., manager, Allyne-Ryan Foundry Co., Cleveland.
Carroll, J. M., superintendent, Aluminum Castings Co., Cleveland.
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Carter, W. C., superintendent Link Belt Co., Chicago.
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Chambers, William, Garden City Sand Co., Chicago.
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Chase, C. M., superintendent, Toronto Hardware Mfg. Co., Toronto, Ont.
Chase, F. D., president, Frank D. Chase, Inc., Chicago.
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CLARK, R. N., sales manager, Rogers Brown & Co., New York.
CLARK, R. W., salesman, Rogers, Brown & Co., Cincinnati.
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EVANS, JAMES E., salesman, S. Obermayer Co., Chicago.
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HALEY, HUTTON, H., district manager, American Foundry Equipment Co., New York.
HALFAHER, W. A., superintendent, Kansas City Hay Press Co., Kansas City.
HALIN, WILLIAM, foundry superintendent, Henry Wray & Son, Rochester, N. Y.
HALL, A., foundry foreman, Wellman-Seaver-Morgan Co., Cleveland.
HALL, ALEXANDER, superintendent, Lynchburg Foundry Co., Lynchburg, Va.
HALL, JOHN H., engineer, Taylor Wharton Iron & Steel Co., High Bridge, N. J.
HALL, LOUIS J., Columbia Bronze Corp., New York.
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HALLOWELL, WILLIAM S., Harrison Safety Boiler Works, Philadelphia.
HAMEL, F. W., salesman, International Molding Machine Co., Chicago.
HAMEL, G. L., general foundry foreman, Canadian Steel Foundry, Montreal, Que.
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HAMMER, F. L., assistant superintendent, Steel Foundry, Malleable Iron Fittings Co., Branford, Conn.
HAMMERSTROM, WILLIAM G., manager, Stroh Casting Co., Detroit.
HAMMOND, GEORGE, H., foundry superintendent, Taylor Forbes Co., Guelph, Ont.
HAMMOND, ROBERT S., sales representative, Whiting Foundry Equipment Co., Pittsburgh.
HAMMOND, T. S., secretary, Whiting Foundry Equipment Co., Harvey, Ill.
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HANSON, GEORGE, president, Havana Mfg. Co., Havana, Ill.
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HARRISON, A. E., assistant works manager, Allis Chalmers Mfg. Co., Milwaukee.
HARRISON, F. Y., superintendent, Murphy Iron Works, Detroit.
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HART, L. O., second vice president, Driver-Harris Co., Harrison, N. J.
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HATTEN, JAMES H., salesman, G. F. Pettinos, Philadelphia.
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HENDRI, R. J., foreman, S. H. Barnum, New Haven, Conn.
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HIBBENS, T. A., sales manager, Stevenson Co., Wellsville, O.
HIBBS, JOSEPH S., assistant general manager, J. W. Paxson & Co., Philadelphia.
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HILL, JOHN, the Hill-Brunner Foundry Supply Co., Cincinnati.
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HILLIARD, HENRY F., foreman, Essex Foundry, Newark, N. J.
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HOCHGESANG, C. E., foundry foreman, American Saw Mill Machinery Co., Hackettstown, N. J.
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HOFFMAN, L. G., works manager, Alberger Pump & Condenser Co., Newburgh, N. Y.
HOFFMAN, PAUL, foreman, Flockhart Foundry Co., Newark, N. J.
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JOHNSTON, E. D., president, P. H. & F. M. Roots Co., Connersville, Ind.
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JOHNSTON, S. T., vice president, The S. Obermayer Co., Chicago.
JOHNSTON, W. S., foundry foreman, Pittsburgh Valve & Fittings Co., Barberton, O.
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JONES, A. H., works superintendent, American Woodworking Machinery Co., Rochester, N. Y.
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JONES, EDMOND, iron foundry foreman, Fairbanks Valve Co., Binghamton, N. Y.
JONES, FRANKLIN S., foreman, Worthington Pump & Machine Corp., Holyoke, Mass.
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JORDAN, R. F., Boston manager, Sterling Wheelbarrow Co., Milwaukee.
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KAHN, BERTRAM B., works manager, Estate Stove Co., Hamilton, O.
KAINE, WALTER F., president, T. P. Kelly & Co., Inc., New York.
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KAVENY, THOMAS, president, Herman Pneumatic Machinery Co., Pittsburgh.
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KAYE, E., director, Federal Foundry Supply Co., Cleveland.
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KELLER, JOHN F., foundry superintendent, Homer Furnace Co., Homer, Mich.
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KELLY, A. E., salesman, Debevoise-Anderson Co., New York.
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KELLY, PATRICK, foreman, Utica Heater Co., Utica, N. Y.
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KENNEDY, JOSEPH P., president, Kennedy Foundry Co., Baltimore.
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KENNERY, MARTIN H., foundry superintendent, North & Judd, New Britain, Conn.
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KERN, R. B., Link Belt Co., Philadelphia.
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KLINE, J. F., Cresson Morris Co., Philadelphia.

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KRAMER, GEORGE H., president, Kramer Bros. Foundry Co., Dayton, O.

KRANZ, FRED A., Lycoming Foundry & Machine Co., Williamsport, Pa.

KRAUSS, F. V., president, Portsmouth Stove & Range Co., Portsmouth, O.

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LANDSDOWNE, D. P., vice president and secretary, West Steel Casting Co., Cleveland.
LANE, G. H., York Mfg. Co., York, Pa.
LANE, H. M., president, H. M. Lane Co., Detroit.
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LASSEN, C., Smidth-Lewis Foundry, Inc., Elizabeth, N. J.
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LAW, B. N., Chicago district manager, Air Reduction Sales Co., New York.
LAWLOR, J. J., superintendent, Union Foundry Co., Pittsburgh.
LAWS, H. M., assistant foundry superintendent, Eastern Malleable Iron Co., Wilmington, Del.
LAWTON, L. H., general manager, Jonathan Bartley Crucible Co., Trenton, N. J.
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LEPHART, R. P., vice president and general manager, Richmond Structural Steel Co., Richmond, Va.
LESH, I. B., general superintendent, Railway Materials Co., Toledo, O.
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LOCKE, J. H., assistant to general manager, Commonwealth Steel Co., St. Louis.
LODGE, W. J., vice president, Lodge Mfg. Co., S. Pittsburgh, Tenn.
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McKinnon, H. L., C. O. Bartlett & Snow Co., Cleveland.
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McWane, L. H., president, Lynchburg Foundry Co., Lynchburg, Va.
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MARTIN, H., foreman, Flockhart Foundry Co., Newark, N. J.
MARTINS, H., president, Enterprise Foundry Co., San Francisco.
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MEISTER, W. F., general manager, Patten Bros. Co., Marietta, O.
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MERKEL, H. HAYS, salesman, Treadwell Engineering Co., Easton, Pa.
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MEYER, ADOLPH, foreman, Sweet & Doyle Foundry & Machine Co., Green Island, N. Y.
MEYER, L. R., foundry superintendent, Inter-State Car Co., Indianapolis, Ind.
MEYER, P. A., salesman, General Electric Co., Philadelphia.
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MILLER, C. C., Dodge Bros., Detroit.
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MOORE, FRED, foreman, Steacy Schmidt Co., York, Pa.
MOORE, FRED C., general manager, Vermillion Malleable Iron Co., Hoopeston, Ill.
MOORE, G. W., E. A. Moore Foundry, Reading, Pa.
MOORE, H., superintendent, Atlantic Radiator Co., Huntington, Pa.
MOORE, J. D., vice president, Hauck Mfg. Co., Brooklyn, N. Y.
MOORE, ROBERT E, vice president and treasurer, Flockhart Foundry Co., Newark, N. J.
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MUNN, L. L., secretary, Arcade Mfg. Co., Freeport, Ill.
MUNTZ, C., vice president and general manager, Tropenas Converter Co., Brooklyn, N. Y.
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Newcomb, Robert E., superintendent, Worthington Pump & Machinery Corp., Holyoke, Mass.
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RAUSCHENBERG, C., superintendent, Wheeling Mold & Foundry Co., Wheeiing, W. Va.
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REED, R. B., sales manager, Young Bros., Detroit.
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ROBINSON, G. D., Buffalo sales manager, United States Graphite Co., Saginaw, Mich.
ROBINSON, L. P., New England manager, Werner G. Smith Co., Cleveland.
ROBINSON, ROBERT C., salesman, J. W. Paxson Co., Philadelphia.
ROBINSON, S. R., Philadelphia Roll & Machine Co., Philadelphia.
ROBINSON, W. B., Pittsburgh manager, *The Iron Age*, Pittsburgh.
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ROE, L. M., sales agent, American Car & Foundry Co., Huntington, W. Va.
ROE, WILLIAM J., superintendent, Stroh Casting Co., Detroit.
ROGERS, A. L., foreman, United Shoe Machinery Co., Beverly, Mass.
ROGERS, P. C., superintendent, Union Steel Casting Co., Boston.
ROGERS, WILLIAM J., superintendent, Lycoming Foundry Co., Williamsport, Pa.
ROHE, V. J., sales manager, T. P. Kelly & Co., Inc., New York.
ROHLEDER, J. C., foreman, Sweet & Doyle Foundry & Machine Co., Green Island, N. Y.
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ROMLERVSKI, ALFONS, foreman, Wheeler Condenser & Engine Co., Carteret, N. J.
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ROSE, ROBERT, foreman, Buffalo Foundry & Machinery Co., Buffalo.
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ROSS, H. A., president Ross Tacony Crucible Co., Philadelphia.
ROSSITOR, CLARK, general superintendent, Phoenix Iron Works Co., Meadville, Pa.
ROTHE, JOSEPH F., president, Joseph F. Rothe Foundry Co., Green Bay, Wis.
ROTTACH, J., superintendent, Taylor & Co., Brooklyn, N. Y.
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RYAN, F. J., general manager, American Metallurgical Corp., Philadelphia.
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RYAN, JOHN T., foundry foreman, Walter A. Wood Co., Hoosick Falls, N. Y.
RYAN, WILLIAM, foundry foreman, W. H. Jackson Co., Brooklyn, N. Y.
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SMITH, FRANKLIN G., president and general manager, Cleveland Osborn Mfg. Co., Cleveland.

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SMITH, JAMES S., secretary and treasurer, The Smith Facing & Supply Co., Cleveland.
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SMITH, S. A., representative, William Sellers & Co., Philadelphia.
SMITH, WERNER G., president, Werner G. Smith Co., Cleveland.
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STANDER, H. A., purchasing agent, Damascus Bronze Co., Pittsburgh.
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STARK, WILLIAM, superintendent, A. Garrison Foundry Co., Pittsburgh.
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STAY, F. D., aluminum Castings Co., Cleveland.
STEBBINS, CHAS., president, Jefferson Union Co., Lexington, Mass.
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STERLING, JAMES S., manager, Hilles Jones & Co., Wilmington, Del.
STODDER, W. F., Straight Line Engine Co., Syracuse, N. Y.
STONEY, JOHN T., foundry manager, Ferro Machine & Foundry Co., Cleveland.

STOOP, WILLIAM, foundry foreman, J. L. Mott, Trentôn, N. J.
STORIE, A. G., foundry manager, Fittings Ltd., Oshawa, Canada.
STRANGWARD, WILLIAM J., general manager, Walworth Run Foundry Co., Cleveland.
STREET, HARRY S., general labor foreman, Bethlehem Steel Co., Steelton, Pa.
STREET, HORACE R., superintendent, Interstate Foundry Co., Cleveland.
STRICKLAND, A. C., general manager, Strickland Machine Co., Richmond.
STROH, B., JR., president, Stroh Casting Co., Detroit.
STRONG, WALTER R., salesman, Norton Co., Worcester, Mass.
STRUNK, JACOB, foreman, temple Malleable Iron & Steel Co., Temple, Pa.
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TAYLOR JR., H. B., George F. Pettinos, Philadelphia.
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TAYLOR, H. T., salesman, E. J. Woodison Co., Detroit.
TAYLOR, J. S., sales manager, Taylor Forbes Co., Ltd., Guelph, Ont.
TAYLOR, W. E., president, Taylor & Co., Inc., Brooklyn, N. Y.
TAYLOR, W. H., western manager, Ross Tacony Crucible Co., Philadelphia.
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THOMAS, A. O., vice president, H. M. Lane Co., Detroit.
THOMAS, L. E., president, Reading Iron Co., Reading, Pa.
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Voneman, J. H., foundry foreman, Hoover Suction Sweeper Co., North Canton, O.
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